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THE LATEST TUNNEL CONNECTION NEAR THE CHICAGO AVENUE PUMPING STATION, CHICAGO WATER WORKS.

BY HENRY W. CLAUSEN, C. E.*

There is probably no piece of ground in the world containing as many tunnels of various sizes, shapes and elevations as the property upon which the Chicago Avenue Pumping Station is located.

This condition of affairs has been brought about by added changes and extensions from time to time due to the growth of the Chicago Water Works System.

The subject of this article deals with the latest and probably the most difficult extension thus far constructed.

Originally the 22nd street pumping station of the Chicago Water Works was supplied with water from Lake Michigan by means of a 7-foot tunnel extending from the Two-Mile Crib in Lake Michigan to the pumping station.

This 7-foot tunnel extended from the Crib located in Lake Michigan two miles east of Chicago avenue to a shore shaft, known as Shaft *F*, just outside of the Chicago avenue pumping station, at East Chicago avenue and Lincoln Parkway, and from this shaft diagonally across the city to the 22nd street pumping station located at South Ashland avenue and West 22nd street.

The construction of this tunnel was commenced in 1872 and completed in 1875. The portion between Shaft *F* and the 22nd street pumping station is from 60 to 80 feet below the surface, the idea at that time being that it was considerably below the level of any building foundation that might be constructed over it.

Due to the adoption of concrete caissons extending to hardpan or rock for large building foundations constructed in the "Loop," various private property owners discovered its exist-

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ance and it became necessary to abandon the land section of this tunnel. Accordingly, the Blue Island avenue tunnel was constructed, to replace this section with an alignment following the public streets.

The Blue Island avenue tunnel was put into operation during the year 1909, after which time the old Cross-town tunnel was abandoned.

It being the experience that the cost of maintaining the Two-Mile Crib was excessive, plans were considered in 1907 and it was practically then decided to abandon this crib by constructing a new crib farther out in the lake and to extend the three tunnels supplied by the Two-Mile Crib to the new crib.

With this end in view, the Blue Island avenue tunnel, 8 feet in diameter, was commenced, with the sinking of Shaft No. 1, located in Delaware place, just east of Lincoln Parkway.

A stub was extended easterly from this shaft 440 feet, it being the intention at some future date to extend this tunnel out to the above mentioned new crib.

In order to supply water temporarily to the Blue Island avenue tunnel, a connection was driven south in Lincoln Parkway from Delaware place and around the Chicago avenue water tower to a connection with Shaft *M* outside of the Chicago avenue pumping station.

In practical operation it was found that the water taken from this shaft was lowering the level of the water in the wells of the Chicago avenue pumping station, thus interfering with its supply, as well as with that of the 22nd street station.

This became particularly acute during the year 1911-1912, when the capacity of the 22nd street pumping station was increased from 60 to 100 million gallons per 24 hours by means of the addition of two 20 million gallon electrically driven centrifugal pumps.

Samples of water taken at the Two-Mile Crib show water equally pure with those taken at other cribs located farther out in the lake.

By means of the use of compressed air for fighting anchor ice at the Two-Mile Crib, it has been possible to reduce the

cost of operation of this crib so that it compares favorably with the operating cost of the cribs of more modern design.

These facts, together with the fact that there were two perfectly good 7-foot tunnels between the Two-Mile Crib and the Chicago avenue pumping station, which were not delivering anywhere near their capacity, due to restricted tunnel connections at the pumping station, as may be seen in Fig. 1, caused a revision of plans during the early part of 1912.

It was discovered that a tunnel connection could be made between the Blue Island avenue tunnel and the lake section of the old 7-foot Cross-town tunnel which would restore to the 22nd street pumping station its former source of supply un-

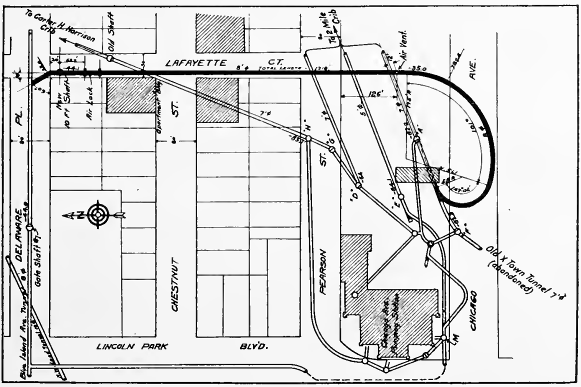


Fig. 1.

restricted, the same as was the case before the construction of the Blue Island avenue tunnel.

The problem was very much complicated aside from the engineering difficulties of alignment, because it involved the sinking of a shaft and the construction of a tunnel through soft, blue clay adjacent and close under two apartment houses, the crossing of four water tunnels in operation and under lake pressure, three of which were passed over with from 14.5 feet to 18 feet of clay intervening, necessitating the use of air pressure.

The alignment of the tunnel connection and profile are shown in figures 1 and 2.

Shaft Construction.

In starting the excavation for the shaft a hole 16 feet square was first opened up 10 feet below the surface for placing the steel shell. Two inch planks, for sheeting, were driven around all four sides of the excavation, and held in place by three sets of timber frames placed 3 feet apart vertically.

Water was encountered at this depth, and the excavation was interrupted until the first section of the steel shell could be placed.

The steel shell is a hollow cylinder of 3/8-inch boiler plate, 11 feet 5 inches in diameter, and 30 feet long, with both ends open. It was made in five 6-foot sections.

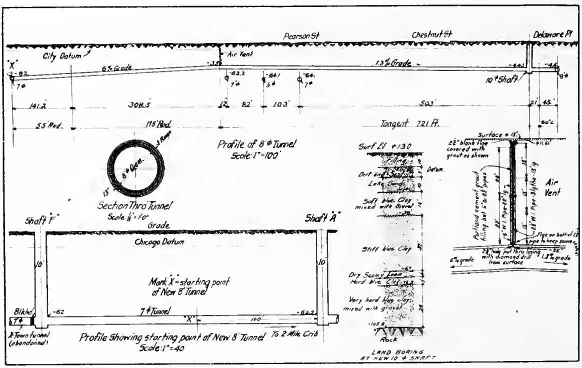


Fig. 2.

The two bottom sections were riveted together in the shop and provided with a beveled cutting edge stiffened around the inside with an additional plate and a 6x8-inch angle one foot above the cutting edge. The total weight of the shell was 21,385 pounds.

The idea of using this shell was to insure the construction of a dry shaft as a stratum of water-bearing sand was known to exist 12 feet below the surface.

Each section of the shell was thoroughly calked and all the rivets were countersunk on the outside.

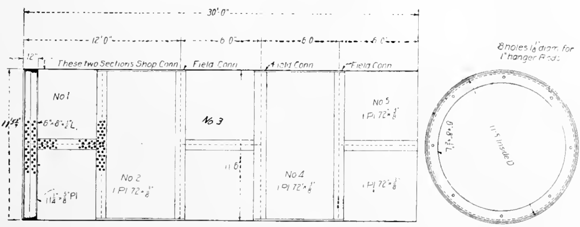
The two bottom sections were first placed in the square excavation above described and lined up by means of vertical

guide timbers on four sides. The third section was then added and the brick lining started, the 6x8-inch angles serving as a footing.

With the additional weight of the lining in the three sections, the shell was forced down to elevation—4, or 16.6 feet below the street grade.

Preparations were then made to sink the 18 feet of erected shell deep enough to permit the erection and riveting of the remaining two sections.

A No. 4 Nye pump was suspended within the shell as the material first to be excavated was the water-bearing stratum of the lake sand, previously referred to. This sand was 13 feet deep, overlying the soft, blue clay, through which the balance of the shaft was sunk.



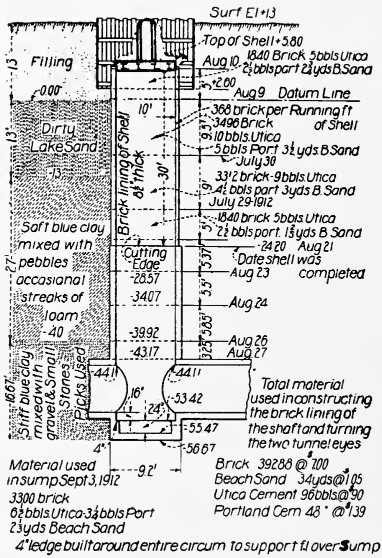
Details of Steel Shell used for shaft.

After excavating the sand from within the shell, it finally settled sufficiently so that the remaining two sections could be added. The 8½-inch brick lining for the entire 30 feet of shell was then completed. The excavation within the shaft was then resumed, no additional weight to the shell being necessary other than the brick lining to sink it to the soft clay stratum encountered at elevation—30 feet, C. D.

At this stop it became necessary to put on an additional weight of 20 tons of pig iron which was loaded on 10x10-inch timbers, placed across the top of the shell. With this additional weight the cutting edge of the shell was sunk 4 feet farther.

In this manner the excavation was continued and more iron added until 82 tons had been loaded on top of the shell, and the cutting edge forced to a final depth of —24.2. It had then penetrated 11 feet into the soft, blue clay, which then closed around the shell and effectually shut off the water.

The weight on the shell was then removed and excavating for the shaft carried 20 feet below the cutting edge, or to the top of the tunnel bore, and a brick lining from 13 inches to 18 inches thick was placed after each day's excavation. The brick lining was suspended by eight 1-inch hanging rods having plate washers. Each rod had an eye at its lower end, which supported the washers and provided for hooking on the



Sketch of shaft as actually constructed.

next rod below. In the 6x8-inch angle, which supported the brick lining for the steel shell, short eye bolts were placed before any brick work was started, and to these were attached the first set of rods.

The shaft was then carried down to its full depth and the two tunnel eyes excavated and lined 10 feet each way from the shaft.

The total cost of the shaft was as follows:

39288 sewer brick, @ $7	$ 275.00
34 cu. yds of beach sand, @ $1.05	35.70
96 bbls. of Utica cement, @ 90c	86.40
48 bbls. of Portland cement, @ $1.39	66.72
3,000 ft. BM Lumber, @ $25	75.00
Steel shell	930.00
Hanging rods, etc.	50.00
Labor and teams	3156.18
Cast iron shaft cover	142.69
Steel beams, miscellaneous labor and material for finishing top of shaft to grade and general cleaning up	182.31
Total	$5000.00

Total depth of shaft below the surface is 68½ feet, making the cost of same $73 per foot.

Tunnel Construction.

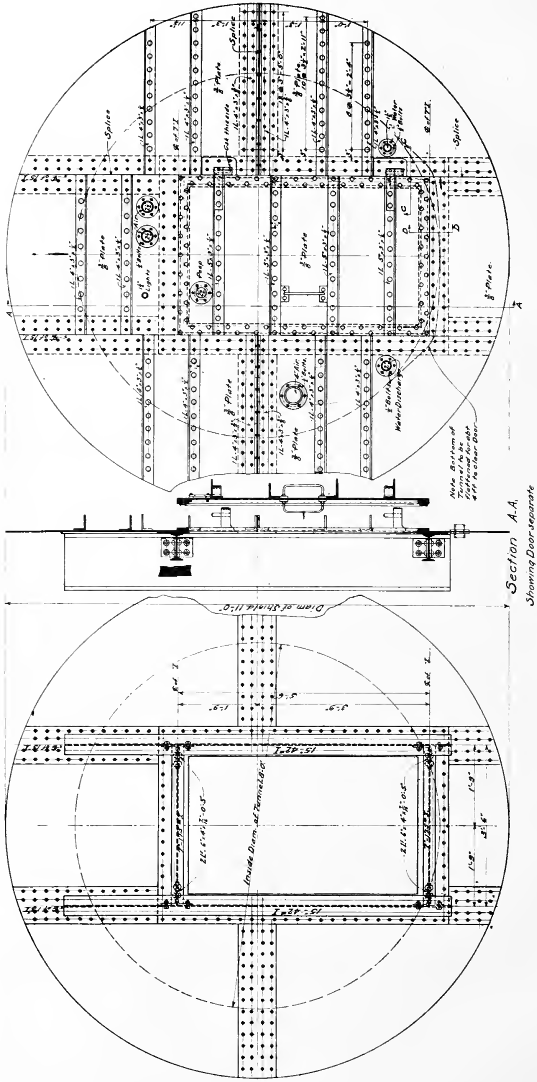
After the shaft had been carried down to its full depth and the two tunnel eyes excavated and lined 10 feet each way from the shaft, the work of driving the tunnel south from the shaft was started in earnest.

Between stations 0+63.2 and 0+82.9, south from the shaft, an air lock was constructed, the excavation up to this point being carried on under normal atmospheric conditions.

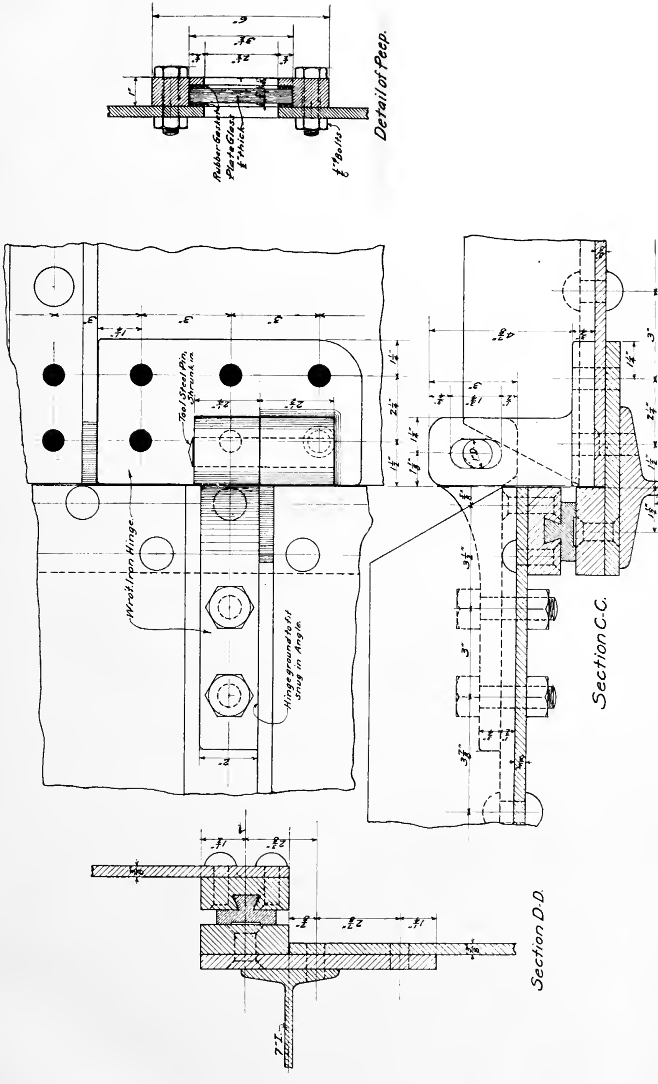
Upon completion of the air lock, the work was carried on under air pressure.

The air lock as built, held two tunnel cars. It was an air-tight compartment, made up in a short section of the tunnel itself, about 22 feet in length. A steel diaphragm with a hinged door large enough to admit the tunnel cars was built across the tunnel at each end. The doors are provided with rubber gaskets around all four edges and both doors swing in the same direction. When in operation, the lock is alternately filled and emptied of air compressed to nearly two atmospheres. Fourteen pounds pressure was usually maintained. The air inlet and outlet valves are at opposite ends of the lock.

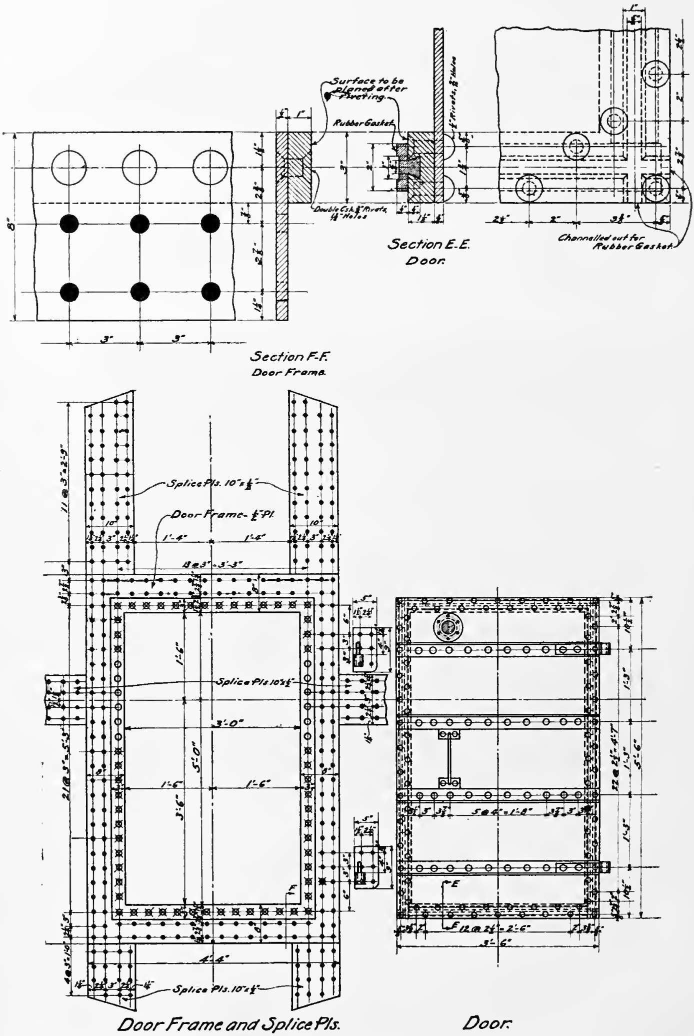
As may be seen from the plan in figure 1, the connection extends south from the shaft for a distance of 700 feet with its center line 10 feet west of the west line of Lafayette court.



Details of Air Lock Diaphragm.

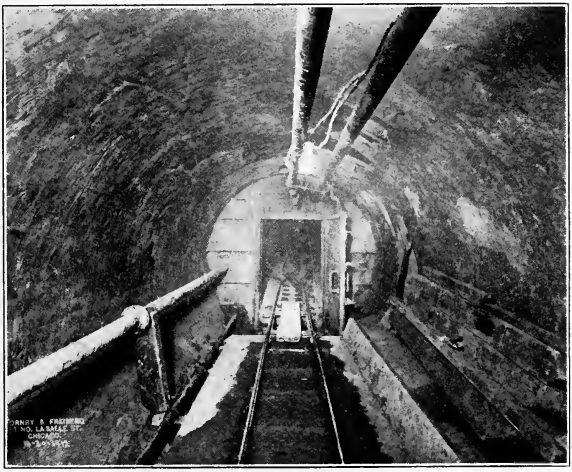


Details of Air Lock Diaphragm, showing Door Hinge, Gasket and Peep Hole.



Details of Air Lock Diaphragm, showing Construction of Door Frame and Door.

At this point it curves to the west on an arc 308.5 feet long on a radius of 175 feet, at the end of which it increases its curvature to the north and extends 141.2 feet on a radius of 55 feet to a connection with the old existing 7-foot tunnel, between Gate Shafts *A* and *F*. At the north end the tangent extends 21 feet north of the shaft and then deflects to the west on a curve of 12 foot radius for 48.25 feet to a connection with the Blue Island avenue tunnel. This deflection was to avoid a right angle connection for hydraulic reasons.



View (looking south, of interior of air lock, Chicago Avenue Tunnel connection.

The grade on which the tunnel is constructed is level between the construction shaft and the Blue Island avenue tunnel. It then rises at a grade of 1.3 per cent from the shaft south to the beginning of the curve whence it dips on a 6 per cent grade to the junction with the lake end of the old Crosstown tunnel. The rising grade was introduced to provide a safe clearance between the new tunnel and the three other tunnels which pass under the new bore, as indicated in Figure 2.

The first of these tunnels is 7 feet in diameter and passes 16 feet below the new tunnel 503 feet from the construction shaft: the second is 5 feet in diameter, 103 feet south of the first, and passes 18 feet below the new tunnel; the third tunnel, 82 feet farther south, lies 14.5 feet below the new tunnel. There is also a fourth tunnel lying 41 feet below the new tunnel, which was crossed at a point 148 feet from the shaft, but

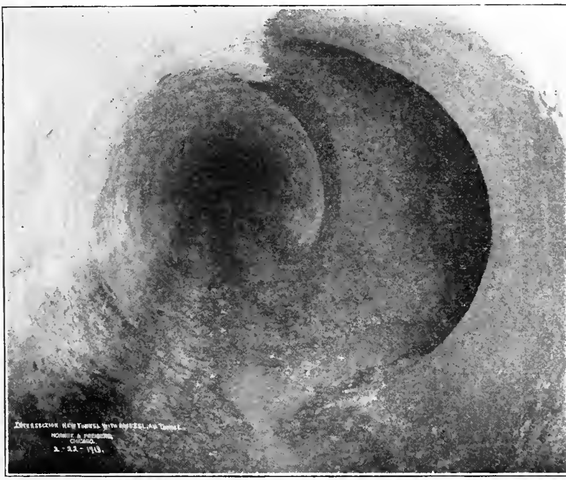
View from point in old tunnel showing connection and reduction in diameter between new and old tunnels. Note the ease of curvature and accuracy of connection.

this tunnel was not necessarily considered when adopting the grade.

The elevation of the top of the tunnel at the shaft is —44.1 feet. At the highest point, 700 feet south of the shaft, the top of the tunnel is at elevation —34.95 feet, and at the intersection with the lake section of the old Cross-town tunnel the top of the tunnel is at elevation —61.94 feet.

The bore of the tunnel throughout its entire length of 1218.94 feet lay in soft blue clay, an ideal ground for holding air pressure and facilitating excavating, the clay knife being used almost exclusively.

The diameter of the bore was made 10 feet 2 inches, to accommodate the three rings of brick work lining the excavation.



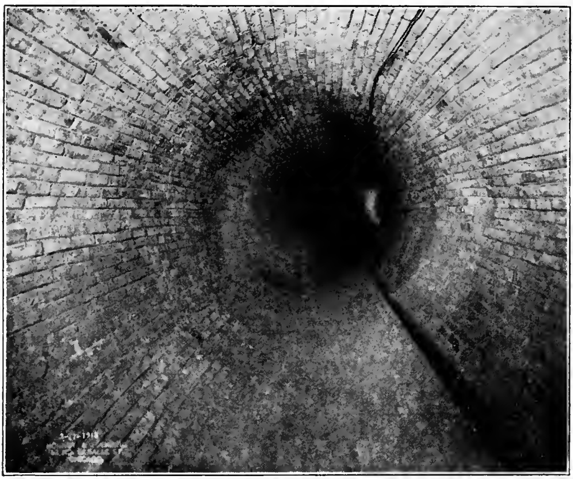
View (looking east) showing connection between Blue Island Avenue tunnel and new tunnel connection.

The mortar used in the brick lining for both shaft and tunnel was mixed uniformly the same, a batch being made up as follows:

2 bags of Utica cement ....2 cu. ft.
2 bags of Universal Portland cement ......2 cu. ft.
3 wheelbarrows of Beach sand.............9 cu. ft.

Or, in the proportion of one of cement to one and one-half of sand.

At the beginning of the work there was some diffiulty with the bricklayers in finishing the work in the manner requested. This was due to the fact that they had been accustomed to work for contractors, being required by them to lay a maximum number of brick within the shortest possible time regardless of the general smoothness and finished appearance of the work. After continual insistences upon changed methods, it was finally possible to obtain brick work, the appearance



View of tunnel on compound spiral curve just before air pipe and electric wires were removed. Note quality of brickwork.

of which compares favorably with good brick work in buildings. It required persistent and continuous effort, however, on the part of the engineers resulting in an education and revelation to the bricklayers themselves.

We have found that it is practically impossible to lay more than 2500 to 3000 brick per bricklayer per day when laid in this way, every brick being thoroughly imbedded in cement mortar.

The finished appearane of this tunnel may be seen from the half-tones included in this article.

The gates in Shafts *A* and *F* were closed at the beginning of the work, leaving a drift about 200 feet long full of water.

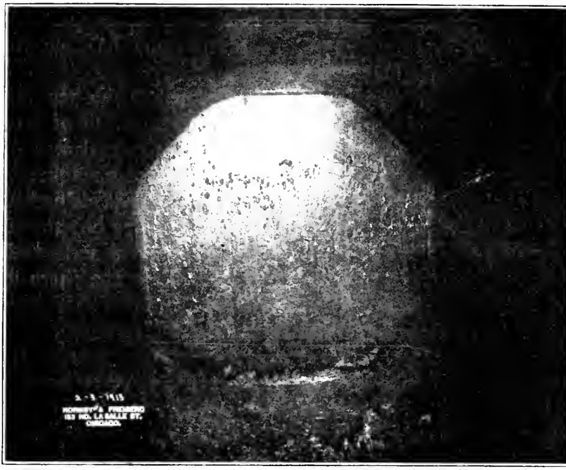
When the connection to this part of the tunnel was first broken through one was able to see the unusual phenomenona of water running uphill without being pumped, the air pressure in the tunnel being sufficient to force the water out through a 3-inch pipe laid in the invert of the new tunnel and passing through the air lock and extending into the atmosphere just north of the lock, a total rise of 27 feet. From this shaft it was pumped to the surface by means of a No. 4 Nye pump.

No trouble from water was experienced at this point after the old drift had once been drained off into the new bore and water pumped to the surface.

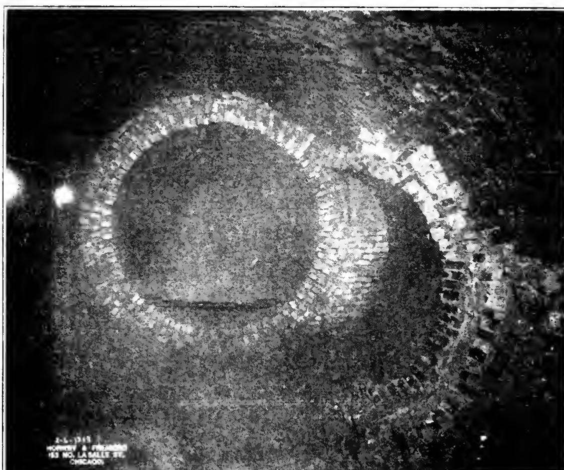
The contraction from 8 feet to 7 feet in diameter of the new and old tunnels was made in a distance of 16 feet.

At station 7+00, at the point of curvature, an air vent was installed, to permit the escape of air when the tunnel was being filled for the first time. This vent consisted of a 6-inch steel pipe sunk from the surface to the top of the tunnel, and the placing of a 2½-inch genuine wrought iron pipe centrally within same, and filling the space between the two pipes with Portland cement grout. By means of a diamond drill a 2⅛-inch hole was put through the tunnel lining upon completion of the grouting. The pipe terminates about 1.4 feet below the surface in a 2½-in blank flange entirely covered with grout. Upon completion of the work, the tunnel was allowed to fill to lake-level on March 5, 1913, the time required for filling being two hours. The air was forced out at the vent for one hour, and then air and water alternately for one-half hour.

At its north end the new tunnel is connected to the 8-foot concrete lined spur of the Blue Island avenue tunnel, extending eastward under Delaware place from Lincoln Parkway, a distance of 720 feet. A gate shaft is located on this spur 282 feet east of the boulevard. The dead end east of this gate was found filled with water when the concrete lined connection with this old end was made. No trouble from leaks was experienced at this end after the dead water was once pumped out.



View (looking northeasterly) of back of tunnel gate in Shaft A, with 60-foot head of water on opposite side of gate.

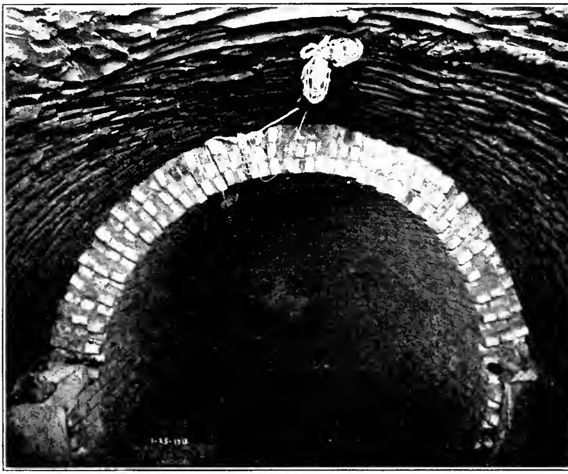


View (looking easterly) from point in old tunnel showing new tunnel approaching connection with old. Note contrast between new and old brick-work.

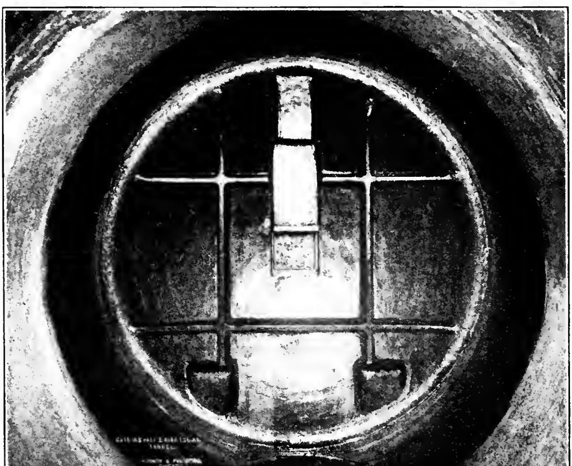
The total equipment used on this job is listed below. The tunnel cars, hoisting cage, head house, etc., were constructed by the city:

Hoisting engine	$ 900.00
Air lock, complete	566.01
Tunnel cars	734.02
Hoisting cage	143.06
Head house (lumber)	155.97
Compressor	114.56
Jack	10.50
Grind stone	2.84
Injector	13.75
Steam gauge	2.87
Lubricator	5.85
Pillow blocks	3.68
36″ cheave wheels	33.57
Rail bender	4.90
Pop safety valve	15.80
Blow-off cock	3.50
Forge	13.68
Chain hoist	25.50
Gong	.75
Fire extinguisher	6.50
Nozzle	.20
Lumber	891.46
Miscellaneous tools	138.98
Pipe, fittings, etc.	547.81
Rails and switches	562.89
Armstrong stock and pipe dies	8.82
1—36″ Stilson wrench	3.60
	$5811.07

It was estimated that the value of the equipment upon completion of the work amounted to $4200. This would make the actual cost of the tunnel and shaft $49,671.95. Subtracting the cost of the shaft, $5000.00, from this amount leaves $44,-671.95 as the cost of the tunnel, or about $37.00 per lineal foot —a moderate figure considering the quality of the work done, the length of the tunnel, the curves and grades upon which it is built, that air pressure was used, and that engineering and inspection costs are all included.



View showing excavation and toothing of tunnel on curve of six per cent grade. Note how snugly the tunnel lining fits the excavation without use of additional material.



View (looking west) at back of tunnel gate in Shaft No. 1 of Blue Island Avenue Tunnel, 50-foot head of water on opposite side of gate.

The following is the total amount of material actually used in the tunnel:

	Total	Cost per foot of Tunnel
Sewer brick, 623,712	$4418.00	$3.624
Beach sand, 599 cu. yd.	650.91	.534
Portland cement, 792 bbls.	1136.88	.933
Utica cement, 1,184 bbls.	983.10	.771
	$7188.89	

The following represents the total engineering and supervision cost of the work:

	Total for job.	Cost per foot of Tunnel and Shaft
Engineering (plans and supervision)	$2701.05	$2.097
Inspection	925.00	.720
Superintendent and foreman	1975.97	1.534
Equipment	5811.07	4.511

The following is a statement of the wages paid to the various trades upon the job:

	Rate per day
Assistant engineer	$ 5.61
Rodman	2.96
Mining inspector	5.00
Superintendent and foreman	8.06
Assistant Foreman	6.00
Bricklayer foreman	11.00
Bricklayers	10.00
Tunnel miners	4.00
Muckers	3.50
Tunnel laborers	3.00
Hoisting engineers	5.80
Firemen	2.90
Carpenters	5.00
Blacksmith	5.00
Watchman	2.50

Heading boss	4.50
Lock tender	4.00
Laborers	2.75
Bricklayer tenders	4.00
Mule and driver	5.50
Electricians	6.00
Double teams	5.50

After putting this tunnel connection into service, it was found that the level of the water in the suction wells at four of the city pumping stations was raised considerably, the stations affected being Chicago avenue, 22nd street, Springfield avenue and Central Park avenue, the latter two being influenced on account of a connection between the Cater H. Harrison tunnel system and the Two-Mile tunnel system, as indicated in Figure 1.

The total saving in coal at the four stations above mentioned amounts to between $4000 and $5000 per year, figured at the pumpage for the year 1912. This saving, together with the possibility of running the 22nd street pumping station at full capacity of 100 million gallons per 24 hours, as was not previously possible, has more than justified the construction of the tunnel.

The work was performed by the Construction Division of the Bureau of Engineering, Department of Public Works, City of Chicago, under the immediate direction of Mr. E. P. Scott, Assistant Engineer. The writer has responsible charge of the Construction Division under Mr. John Ericson, City Engineer, who is the responsible head of the Bureau of Engineering under Mr. L. E. McGann, Commissioner of Public Works.

SPEED CONTROL FOR SMALL MOTORS.

BY HAROLD W. NICHOLS, M. S., E. E.*

In a great many physical measurements one finds it necesary to secure a constant angular speed in some piece of apparatus, and at the same time to have this speed under control over a considerable range. The most convenient machine for driving purposes is the electric motor, and if a very large connected alternating current supply system is available, a synchronous motor will give constant speed, but this is not continuously variable, and, except in large cities, the frequency of the supply system is not sufficiently constant for accurate work. If a direct current shunt motor is used in the ordinary way, variations in the supply voltage will change the speed, and it is a well known and exasperating fact that a constant supply voltage is never practically available, even with a storage battery. The source of trouble in this kind of work is usually not impulsive changes in voltage, but comparatively slow ones, which invalidate readings taken over periods of a minute, for example. It is therefore desirable to devise an apparatus whose speed is independent of such changes in the supply voltage, and which also permits a continuous variation in speed over a wide range.

An arrangement by means of which this may be accomplished is shown in the figure.

Fig. 1.

The armatures of two motors are connected in series across the supply voltage, E, and a resistance, r, is similarly connected. The common armature terminal is connected to a point, P, on the resistance, and divides it into two parts, xr and yr, $(x + y — 1)$. The two motors are alike, and are connected to a differential gear which therefore has a speed

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proportional to the difference in speeds of the two armatures. The two fields are excited from the same supply, so that for small changes in E, the change in field flux is proportional to this change.

Notation.

Angular speeds of motors, ω_1, ω_2.
Angular speed of gear, $\omega = \omega_2 - \omega_1$.
Armature resistance, a.
Currents in armatures, i_1, i_2.
Counter electromotive forces, e_1, e_2.

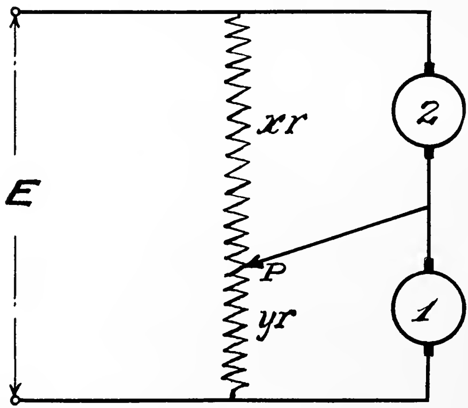

Fig. 1.

With the fields excited as explained, the counter e. m. f. of machine (1) is proportional to w, E for small changes in voltages, hence:

$$e_1 = k\omega_1 E,\ e_2 = k\omega_2 E$$

and it is required to find w in terms of the voltage and currents.

The solution of this network is always possible, and gives:

$$(2arxy + a^2)i_1 = -E\{xyrk\ (\omega_2 + \omega_1) - xyr + ak\omega_1 - ya\}$$

$$(2arxy + a^2)i_2 = -E\{\ xyrk\ (\omega_2 + \omega_1) - xyr + ak\omega_2 - xa\}$$

From these equations, by subtraction:

$$k\omega = x - y - \frac{r(i_2 - i_1)\ (1 + 2\,rxy)}{E}$$

and if now the torques of the two machines be adjusted until the two currents are equal, we have, finally:

$$\omega = \frac{2x - 1}{k}$$

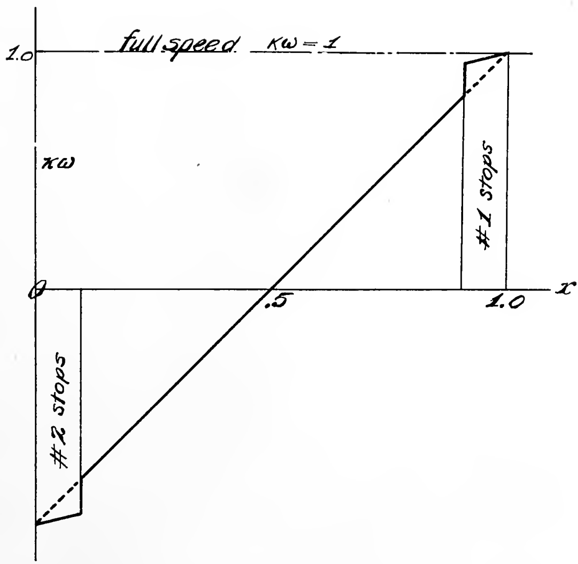

Fig. 2.

The speed ω is thus independent of the voltage, and is capable of variation, since x may vary from zero to unity without violating any of the conditions.

The operation of the set is shown in the curve.

It is not possible to operate on the part shown dotted, since the motor will stop below a speed at which it cannot supply the required torque. At this point the speed will

suddenly rise to that of the running motor—nearly full speed —and then with further variation of x will rise to its full value.

This method is independent of any adjustments requiring a knowledge of the motor characteristics, and since the motors are in any case small ones, the low efficiency is not an objection. Any departures from constant speed will depend upon mechanical imperfections, and the choice of this scheme will depend upon whether it is possible to secure a motor with good mechanical characteristics. The gear used should be chosen so that one motor cannot drive the other by means of it.

THE PRESENT STATUS OF THE PROBLEM OF AEROPLANE STABILITY.

BY SYDNEY V. JAMES, B. S., M. E.*

That the aeroplane in some form or another has come to stay is without doubt in the minds of progressive thinkers. The present state of the art may be looked upon as, at least, a partial solution of the problem of aerial navigation with heavier-than-air machines. The most serious aspect of the question of the future use of aeroplanes deals with the problem of safety and dependability. The loss of human life which has been attendant on the development of the art and science of aeroplaning has been larger than necessary perhaps and may be said to be due in a large part to a lack of fundamental knowledge on the important problem of stability. To be sure many fatal accidents have been due to breakage of vital parts of the mechanism during flight or to failure of the motor in a critical situation, but such diculties are to be overcome by an application of the already well known principles of modern engineering practice. When this has been done we must look to the solution of the stability problem to bring the aeroplane into the sphere of practicability.

Like many other new problems of practical importance there are many ways of attacking the stability situation. Some have preferred to start immediately with a full-size aeroplane and actually try out the new ideas in flight. Others have worked for long periods with small flying models of the proposed design and thus attempted to gain some insight into the relative advantages and disadvantages of various types. Still others who are more especially equipped along theoretical lines have attempted to present to the world mathematical treatments of the problem based on a more or less arbitrary

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set of initial conditions governing the machine in flight. On account of the great complexity of these conditions in actual practice and also of the little understood relations of the forces and directions of the air currents about an aeroplane even under the simplest conditions the value of such mathematical deductions may for the present be questioned.

The first mentioned method, that of trying out ideas on the full-sized aeroplane, seems to have been productive of the most progress to date. It is the method of trial and error and in the hands of careful observers had led to the discovery and successful utilization of many fundamental principles of stability. As ordinarily used by aeronautical writers this "stability" has been stretched to cover a variety of meanings, and a confusion of the proper meaning of "stability" and "equilibrium" has become quite common. It may not be out of place

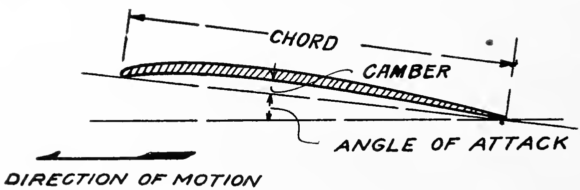

Fig. 1.

here to say by way of review that an aeroplane has stability when it can recover its equilibrium in the face of disturbing conditions. Aeroplane stability may be considered in two broad divisions: (1) Longitudinal stability, pertaining to oscillations about the transverse axis through the center of gravity of the machine, and (2) lateral stability, pertaining to oscillations about the fore-and-aft and vertical axes. The fore-and-aft and vertical axes are so intimately associated in practice when questions of stability arise that it is most convenient to consider them in one division of the subject.

A consideration of these two main divisions of the subject will not be taken up and some of the typical arrangements that have been adopted in practice from time to time will be described. This line of attack will lead us directly to the most interesting and one of the most promising of the recent attempts to solve this great problem, i. e. the Dunne aeroplane.

The longitudinal stability problem has been directly associated with the form of wing section used, ever since the so-called "cambered wing" has been proven to be the most efficient load carrier. Fig. 1 shows a standard wing section such as is used on a well known monoplane and the notation commonly used has been indicated. Since the disturbances in flight are due principally to changes in the relative angle of attack of the wings, the equilibrium of the machine depends

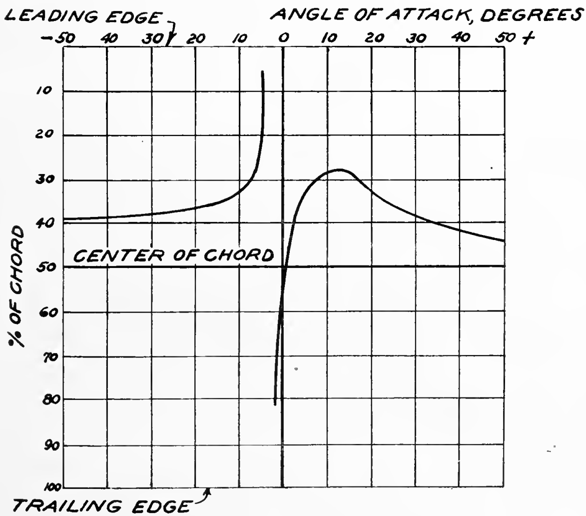

Fig. 2.

on the proper location of the center of gravity relative to the resultant line of air pressure on the wings. Fig. 2 shows the "center of pressure" diagram for the wing section of Fig. 1. Any point on the curve shows the location of the resultant air pressure relative to the leading edge of the wing for the corresponding angle of attack. It will be observed that throughout the range of flying angles (2 to 10 degrees) as the angle increases the center of pressure moves forward. This

explains the instability of the normal wing curve for if a gust of wind should cause the angle of attack to increase temporarily, the front of the machine would be raised due to the couple formed by the air lift and the weight. This would continue to increase until the machine had capsized if no corrective effort was introduced. The action of a decrease of angle would cause the center of pressure to travel backward and introduce a couple tending to drive the machine. This also would increase in effect until the machine capsized if no attempt was made to offset it.

We now come to the description of the various typical means of introducing the required corrective effort. Fig. 3 illustrates diagrammatically an aeroplane with its main lifting surface, *A*, in advance of the auxiliary surface, *B* *B* is a flat surface in the line of flight and has the same effect in pre-

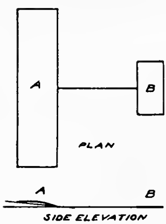

Fig. 3

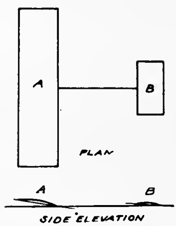

Fig. 4

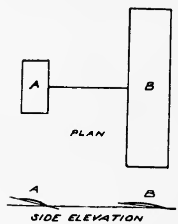

Fig. 6

serving the proper angle of attack as the feathers of an arrow do in maintaining its direction. If the angle decreases the auxiliary surface presents its upper side to the air and the resulting down pressure restores the former conditions. The Nieuport monoplane is an example of the application of this method.

The type illustrated in Fig. 4 has a cambered auxiliary surface *B* following the main lifting *A*. The angle of attack of *A* is larger than that of *B*. The necessity for this may be shown by reference to the curve of wing-lift plotted against angle of attack a typical example of which is shown in Fig. 5. Angle of attack is plotted as abscissa and lift as ordinate. It is easily seen that if the forward wing is set at say 10 degrees and the rear wing at 5 degrees then an increase of angle of

the whole machine of 5 degrees would cause an increase of lift of the front wing represented by *c d* while the rear wing increases by an amount represented by *a b*. From this it is evident that a righting couple is introduced. The same argument applies to a decrease of angle of attack. Hence the fundamental principle of setting the leading wing at a greater angle of attack than the rear wing has come into very general use. A very familiar example of this type is the Bleroit monoplane. It is with a machine of this type that the sensational flights of the Frenchman Pegoud have recently been made.

Fig. 6 shows still another modification of the arrangement known as the "canard" type. This is practically the reverse of

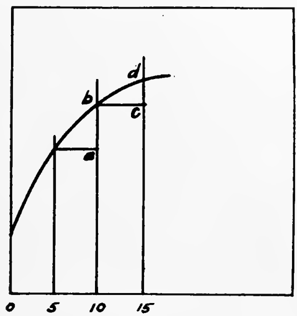

Fig. 5.

the type shown in Fig. 4, but embodies the same general principle of having the leading wing set at a greater angle of attack than the following wing. The "Valkyrie" monoplane formerly built in England, was of this type. Bleroit has recently conducted experiments with a monoplane of this arrangement and has had some encouraging results. As an example of the type built in biplane construction we might mention the Voisin "Canard."

A further modification which has as yet only been experimented with to a small extent is known as the "tandem" type. Langley's machines were of a tandem arrangement, as well as those gliders of Montgomery, but it does not seem that

the proper idea as to the relative angles of attack was evolved in their work. Mr. R. D. Andrews of Boston has conducted some very interesting experiments on tandem surfaces having the leading plane at an angle of attack greater than that of the following plane, obtaining thereby a high degree of longitudinal stability. Fig. 7 indicates the arrangement of a tandem monoplane.

All successful aeroplanes of today embody one or more of the principles included in the above mentioned types and thus possess stability to a greater or less extent lingitudinally which is due inherently to the form and relationship of the supporting surfaces. Many automatic devices have been proposed and some tried out which aim to maintain the longitudinal sta-

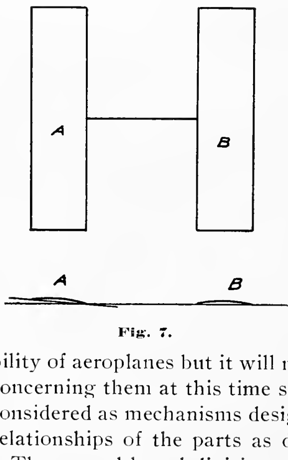

Fig. 7.

Fig. 8.

bility of aeroplanes but it will not be necessary to go into detail concerning them at this time since they may be fundamentally considered as mechanisms designed to preserve the well known relationships of the parts as described above.

The second broad division of the stability problem involves the question of lateral as well as directional stability. The former, lateral stability, refers to oscillations about the fore-and- aft axis of the aeroplane such as would be produced if one wing suddenly tilted up or down, thus rotating the machine about the fore-and-aft axis. Many schemes have been resorted to in the effort to devise an automatic system for dealing with this problem and as some of the devices evolved by trial have partially succeeded we shall briefly consider the

more important of them. Perhaps the oldest idea in connection with this phase of the problem is that known as the lateral dihedral angle. Fig. 8 represents the front view of an aeroplane diagrammatically, *A B* being the front edge of the right hand wing and *B C* that of the other. The angle *A B C* ranges in practice from 160 to 175 degrees. If the aeroplane tilts one way or the other the propected area of the low wing becomes greater than that of the high wing, thus bringing into play a difference in the two wing-lifts tending to right the machine. The device is very effective in calm or relatively calm air, but too pronounced an angle is more of a disturbing element than otherwise when the air is unsteady. Nevertheless many aeroplanes embody in this idea.

Another idea is shown in Fig. 9 and illustrates what is known as the fore-and-aft dihedral angle or "Vee." Fig. 9 is a plan view of the main lifting surfaces of either a biplane or monoplane. Its principle of operation is as follows: when

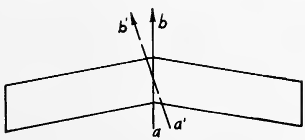

Fig. 9.

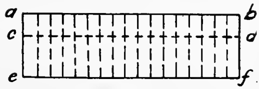

Fig. 10.

the machine takes an inclination about the fore-and-aft axis it commences to slide sideways in addition to its forward movement. Let us assume that the left wing drops, then while the original direction of motion was from *a* to *b*, the resultant motion will be from *a* to *b*. This causes the lift wing to be more effective because its leading edge is now moving at more nearly a right angle to the line of motion than that of the right wing. The tendency is therefore to lift the left wing and depress the right wing thus restoring the machine in its original attitude. Some very sucessful machines employ a design based on this principle. Examples are: Handley-Page and Fokker monoplanes, and the Lohner, Albatross and Dunne biplanes.

Flexible trailing edges are sometimes used to allow the pressure of the air on the two wings of an aeroplane to be equalized. Fig. 10 indicates the idea involved here. The

entering edge of the wing is *ab*, at which place one of the spars is located. The rear spar at *cd* is nearer the front than in the ordinary type of wing thus allowing a greater length for the flexible ends of the ribs from *cd* to *ef*. The ribs between *ab* and *cd* are rigid while from *cd* to *ef* they usually consist of bamboo or other flexible material. A typical example of a successful machine embodying this construction is the Caudron biplane.

Still other devices have been used with more or less success among which might be mentioned fore-and-aft vertical panels between the wings of biplanes similar to the divisions of a box-kite. The early Voisin and Farman biplanes in France used this construction but later discarded it.

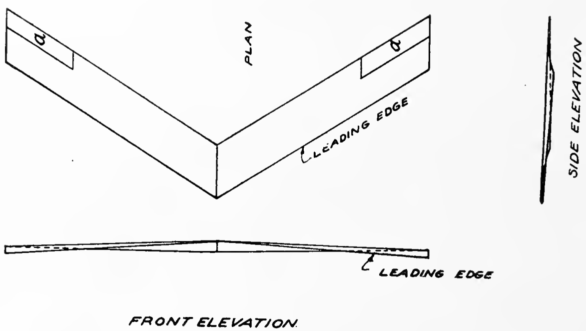

Fig. 11.

We now come to the Dunne machine which has given such a good account of itself in the able handling of Commandant Felix in France. This aeroplane is a biplane having supporting surfaces of a very peculiar form. Fig. 11 shows diagrammatically the shape of the twisted wings. In its usual attitude in flight the angle of attack of the center portion is large, probably about 10 degrees, while that of the tips is slightly negative. This is brought about by a gradual change of angle, always decreasing, from center to tip. In the patent specifications the surface is described as being part of the surface of a cone having its apex outside and to the rear of the wing tip. As will be seen in the cut, the wings

form a "V" in plan form which results in bringing the tips behind the center section. The angle of the "V" is 116 degrees. The front elevation shows that the tips droop slightly below the center portion and being at a small negative angle allow the tops of the wings to be seen as the machine approaches. There are two flaps, *a* and *a*, hinged about their forward edges which comprise the entire controlling system of surfaces. There is no tail surface attached either in front of or to the rear of the wings as is the customary practice with other aeroplanes.

It would require too much space to enter into all the interesting features of this machine but in order to show its relation fundamentally to other types it may be well to point out a few of its more salient features. First of all it has longitudinal stability principally on account of its swept back wings and the fact that the angle of attack gradually changes from root to tip. The latter fact identifies it virtually with the fundamental necessity of having the rear portions set at a less angle of attack than the forward portions of the carrying surface. This was brought out in connection with Fig. 4 preceeding. In the Dunne, however, the tail surface merges imperceptibly into the main lifting portion of the wings. In practice the machine having such wings as the Dunne has remarkable stability and is much easier to control than the usual type of machine.

Considered from the point of view of lateral stability, the Dunne machine with its swept back wings embodies some of the principles discussed in connection with Fig. 9. The peculiar shape of its twisted wings gives it directional stability in that it always has a tendency to head in the direction of the relative wind, thus restoring conditions of symetry as far as the two wings are concerned. Some claim that directional stability should mean the maintenance of the original direction relative to the ground, but this is much more difficult than maintaining the motion in line with the relative wind. The latter is more important from the point of view of safety.

The above reviews in a broad way the general status of the stability situation of today. Of course there are means

employed for correcting the various disturbing effects that air currents have on aeroplanes, such for example as wing warping, ailerons, etc., but these come more strictly under the head of controlling elements rather than belonging to the realm of stability in general. Many of the mechanical and electrical devices brought out for the purpose of automatically operating controlling elements might perhaps be considered in the light of stability devices but as there has not been any great progress along this line their discussion in this article would be out of place.

Broadly speaking there are two schools of thought in regard to the stability problem: (1) those who believe that the solution lies in the stability due to the inherent form and relation of the parts of the aeroplane, and (2) those who believe that the proper thing will be come mechanism to automatically operate the controls. The trend of modern practice points toward the first of these as being the more likely to hold the field of usefulness. The success of the Dunne machine abroad seems to point in this direction.

It is to be hoped that the proper solution may be arrived at soon enough to keep the interest of the public alive to the wonderful possibilities of the new art and science of aviation.

REFLEX STIMULATION OR MANAGEMENT IN ELECTRICAL SHOCK.

BY HENRY BASCOM THOMAS, S. B., M. D.*

The management of emergency electrical shock is of such importance that every engineer should know thoroughly, through practice, precisely the steps needed to save the life of a victim. To have heard a lecture or read a book on the subject is not sufficient. The individual who has the best chances for useful application of his knowledge of resuscitation is the one who has trained himself so that his reflexes prompt the action necessary in recovering one of these unfortunates.

Armour Institute of Technology has a class in the actual practice of resuscitation, so that each student becomes a master of one recognized method, and, therefore, is capable of putting it into execution under the stress of great excitement which so often exists at such accidents.

Shock: When a current of either low or high tension, continuous or alternating, passes through the body under given conditions, and makes certain changes, there is produced a state which we call *electric shock.* The word is familiar to every one, and yet a satisfactory definition can hardly be given.

One theory maintains that in shock there has been a hemorrhage in that part of the brain where the respiratory center is located, and that the blood has caused pressure on the nerve which conveys mesages to the lungs, thus stopping respiration. No doubt the nerve center of respiration is interfered with in shock, but hemorrhage is not the causative factor, for it is not found on examination.

A second theory of the cause of shock is that there is a paralysis of the vasco-motor system, causing a fall in blood pressure, and, in this way, an interference with both the respiration and the heart beat. An interference with the vasco-motor

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system is a condition affecting the muscles of the vessels carrying the blood. Nerves govern the muscles of these vessels, and the failure of the muscle fibres in the vessels to keep up the tension on the blood lowers the pressure in the whole blood system. Such a condition could be serious to the organism if prolonged or intense. It causes anaemia in an organ and, if this is severe, death of the organ follows. Changes of blood pressure do occur in electric shock and have much to do with the condition we call shock, but as yet we have no thorough understanding of the way these conditions are produced.

A third theory in explanation of the cause of shock claims that the condition is due to an influence of the current on the nervous system which interferes with the inhibitory mechanism of the various organs, especially the heart. The terminals of the vagi of the heart may lose their inhibiting power when paralyzed. If we paralyze the terminals of this nerve in the heart of the dog by using atrophin, a drug known to you probably as the one which dilates the pupil of the eyes by paralyzing the muscles of accommodation, the animal loses the cardiac inhibitory power and the heart is in more danger.

A fourth theory is that the electricity passes through and affects the heart muscles themselves, causing contraction of the fibres in an irregular and separate manner to which condition has been given the name, "deadly fibrillary contractions of the heart." It is that part of the heart called the ventricles, the pumps, which are attacked, and when the electricity passes through one side of the heart the other side is influenced just as much and both stop together, showing that the musculature of each is a part of the same mechanism. When fibrillary contractions of the heart occur both the circulation and respiration stop and there is no chance of their returning.

The consequence of a severe electrical shock may be, first, unconsciousness and apparent death, or unconsciousness and real death. Often, following resusciation, or even a shock without unconsciousness, we find changes in the various organs and systems. The nervous system, for instance, often shows a tendency toward paralysis, certain forms of hysteria, pain, numbness, tremors, sickness and headache may be present, also palpitation of the heart, mental confusion, and some-

times even delirium. The eyes may show dimness, a drooping of the lids, change in the size of the pupils, cloudiness of the cornea, defect of the optic nerve and even blindness. The ears may be painful and show altered hearing, slight hemorrhage and a ruptured ear drum. The skin at the point of contact, though it may not show an actual burn, often on close inspection will show altered hair follicles, destroyed tissue, and degenerated skin cells.

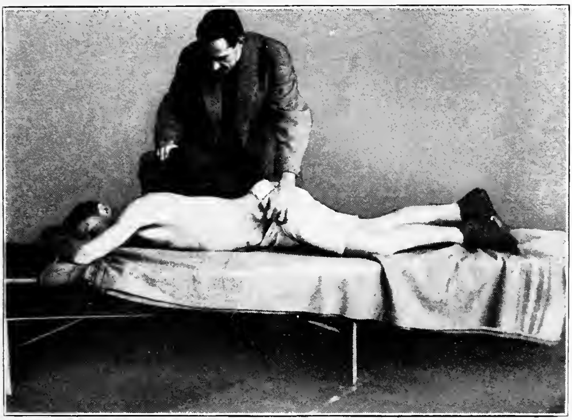

Fig. 1. A victim of an electrical shock will fall in any position. After the current is broken, he should be turned on his abdomen. He should then be raised, as shown in the above cut, so that a sweater or coat may be placed under the right upper chest. This gives the best possible direction to the stomach contents when pressure is made on the chest.

Methods of Resuscitation. The method of Marshall Hall, published in 1857, was to turn the patient upon his chest, then on his right side, the right arm held above his head, then again back on his chest, face downward. This method is often used now, but it requires two men. It is, however, thought especially useful in cases of drowning. It has the advantage of requiring no attention to the tongue and to the mucus in the mouth and throat, for these adjust themselves during the

side position. This method does not aid the groups of chest muscles to expand the chest naturally. The air exchange per minute by this method is said to be about 3.300 c. c.

The method of Sylvester, about which we know a great deal, deals with the patient while he is on his back, and consists of movements of the arms outward and over the head, then downward with pressure against the chest. These movements are repeated about as often as one takes a breath, or twelve to fifteen times per minute. The air exchange per

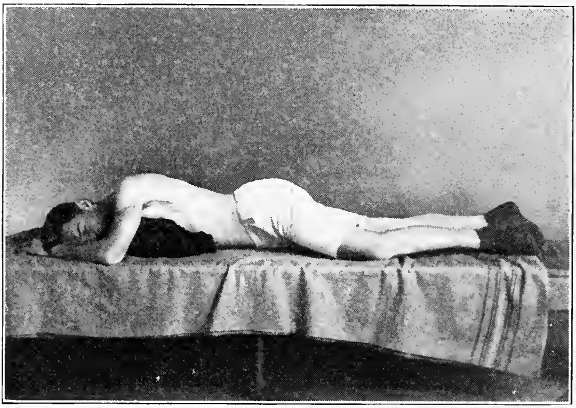

Fig. 2. Here the patient lies with the sweater or coat under the chest in best position possible for the movements of resuscitation.

minute by this method is said to be about 2,280 c. c.

Howard's method, known as the Pressure Method, consists in putting the patient on his chest and making pressure on the back, then turning him on his back and making pressure on his chest, then drawing the arms about him and again making pressure. The advantages of this method are that it empties the throat of mucus when the patient is turned on his face, and allows the tongue to fall forward. But, as a whole, it is not recommended. It is rough, and apt to be dan-

gerous. The air exchange per minute by this method is said to be 4,000 c. c.

In the method of Shafer, the patient is turned on his chest with his face to one side, and the operator kneels astride the patient or at his side at the level of his pelvis, placing his hands on the patient's back and bending his own body forward, making pressure on him. This compresses the abdomen and pushes up the diaphragm. Shafer claims that the air exchange per minute by this method is 6,700 c. c. These manipulations

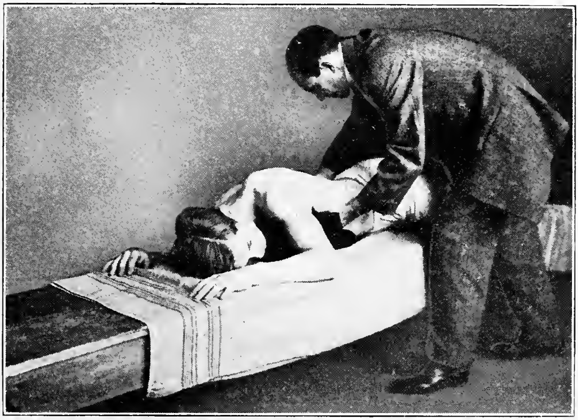

Fig. 3. This cut shows the left hand of the manipulator placed on the side under the arm, a little high and somewhat in front, and the right hand placed on the right side low on the ribs. The position here shown is the first position in resuscitation.

compress the abdomen and lower the chest, but at the risk of the liver, spleen and kidneys, and certainly do not allow any of the delicate mechanism of the upper chest to aid. Neither do the pectoral muscles help to enlarge the thorax, and the diaphragm aids only in emptying the lungs; not in expanding the thorax so air may rush in.

There are no end of new methods and combinations of former methods, but the best procedure for the electrical engineer to study is the following:

In the management of a case of unconsciousness, apparent death, or death from an electric current, the man with a cool head will do two things instantly. First, break the circuit and separate the victim from the wire. Second, begin artificial respiration.

(1) If there is a contact, break it. A handful of dry waste, a bunch of dry old clothes, a dry coat, or a thick piece of dry

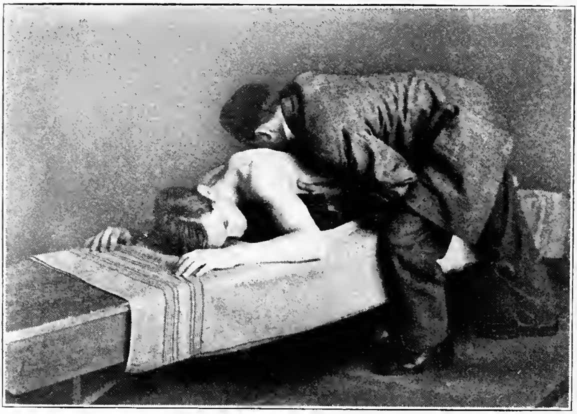

Fig. 4. This cut shows changed position of the operator, by which movement the lung is exhausted of air. From this position the operator should spring back easily to the position shown in Cut 3, and these two motions should continue gently about as often as the operator himself breathes.

These four cuts represent the best method of resuscitation that can be given when there is only one operator on the ground.

carpet, may be used in pulling the victim away from the wire, or the wire away from the victim.

One should hurry, cautiously protecting himself all the time. Do not touch the skin of the victim. If in a laboratory prepared for accidents, put on a pair of rubber gloves, which should be hanging near, and quickly pull the victim away from the wire. If his hand is about the wire, loosen it

cautiously. A wooden hook on the order of an old shepherd's crook, but much larger, should be kept handy, it could be used to advantage in pulling the victim away from the contact. Break the circuit quickly, and begin artificial breathing.

(2) Place the patient on his right side-chest, with the face turned toward the left side, as indicated in the cuts. This can be done by placing a coat or pillow under the left chest.

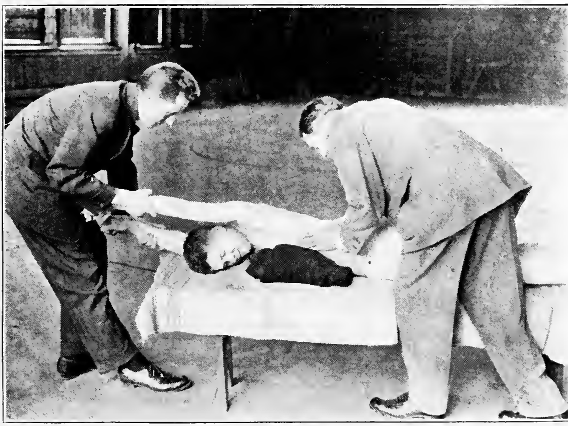

Fig. 5. If, however, help arrives, a physician should be telephoned. Then this help should take part in the resuscitation and make it possible to begin manipulation as shown in Cut 5, in which Operator No. 1 repeats what he has done in the former cuts, and Operator No. 2 assists by raising the arms high over the head, as shown above.

The arms are to lie half-flexed, with hands above the head. This position differs only slightly from Shafer's position. The body is so inclined as to put the stomach in a position which will favor the emptying of its contents into the intestines, rather than into the gullet and trachea, with the probabiliy of aspiration pneumonia. Kneel on the left side of the patient near his waist; place the left hand over the left ribs slightly anterior to the axillary line. This position will aid in the massage of the heart. The right hand should be placed over the

lower right ribs, just posterior to the axillary line. Now make pressure by leaning your own body forward, until your chin almost touches the body of your patient; then spring back carefully to your first position. Repeat this motion every twelve to fifteen seconds until a physician comes, even if for hours.

If there is help near, after you are well under way with this side-back pressure, have a man kneel behind the patient and draw his arms back over his head. This is best done by

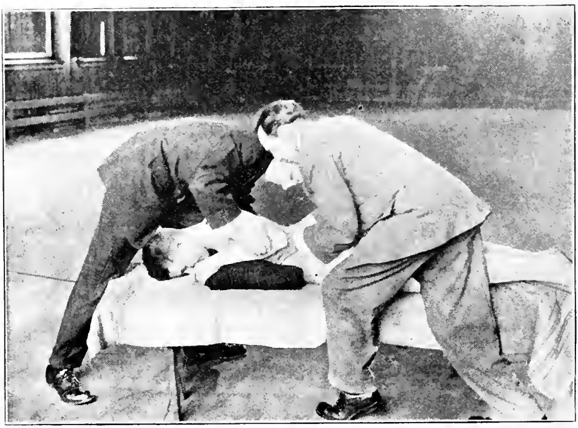

Fig. 6. Then both operators make pressure, the first operator upon the chest wall, as indicated in former charts, and the second operator also upon the chest wall, but through the arms.

grasping the elbows with the forearms bent, and drawing them upward, not backward. At the same time, the side-back pressure should be made on the sides of the thorax by pressure on the arms of the patient, as demonstrated in the cut. All these movements should be repeated about fourteen times per minute.

While giving such movements, make a general inspection of your patient; turn the head well to the left, loosen

the collar bands and the trousers; run your finger in the mouth and empty it of gum, tobacco or false teeth. If there is difficulty in opening the mouth, do not persist, but keep your respiratory movements regular. If more helpers are at hand, order one to empty the mouth and draw out the tongue. In drawing out the tongue, make pressure down and out, not up and out, as upward stretching will only put on the unyielding ligament; while a downward direction pulls the muscle mass out of the throat and allows the mucus to flow out and the air to go in. These movements of the tongue should be regularly made every 30 seconds, for they probably aid in reflexly stimulating the respiration center. Be gentle in making these movements. Be careful, using a dry towel or handkerchief, and you will not have to put a thread through the tongue, as is advised by some. Another helper should make friction, by means of a rough towel or his hands, over the legs and keep the patient warm with artificial heat. Always remember, however, that unconscious people are easily burned with hot water bottles, hot bricks, etc. Often they have no feeling and cannot draw a burning limb away from the heat.

If the patient can be put upon a large table, with his head near one end, it makes the work much easier for the operator. This may be necessary when we work with a patient for hours, but it should not be done if it interferes with the work of resusciation.

Remember, also, that an unconscious person shows no resistance to pressure. The muscle fibres of none of the organs are on guard, and they will not stand the same pressure and roughness you can give your companion when practicing on him. The liver has been ruptured in artificial respiration, and ribs have been broken.

Stimulants should be given only by order of a physician.

Every student of electricity should want to know what to do in case of accident. Regret will not follow sincere attempts to learn. Every one of us should practice a given method of resusciation. This can be done in sections in the

gymnasium, and should be required of every electrical student. Later, an examination should be given to test the student in this work, and in the Senior Year pictures of the positions in resuscitation should be given to the graduating class to recall the subject to their minds.

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TERMS OF SUBSCRIPTION.

THE ARMOUR ENGINEER, four issues, postage prepaid........$1.00 per annum

Every year added to the life of a publication makes it better and more adapted to the needs of its reading constituency. The sixth year is bringing forth four issues of *The Armour Engineer* introducing a more extensive department of "Alumni Notes," which we hope will be welcomed by the members of the Armour Alumni Association. It is practically the only means by which members are able to communicate with one another. To the students we may say that through the med-

ium of *The Armour Engineer* you are able to acquaint yourselves with men of authority in your profession.

We endeavor to continue to publish original articles of commercial importance of the same high standard and excellency as have been published in the past, ranking *The Armour Engineer* as one of the leading technical journals of the west. Co-operation of the faculty and alumni has made this possible. We wish to thank them for their results, which we assure them will be appreciated by their Alma Mater.

One of the most promising fields for the engineering graduate lies in mechanical refrigeration. There are greater opportunities in this branch of engineering at present than in any other, not barring automobile engineering and the allied industries. The importance of this field is evidenced by the number of Governments officially represented at the Third International Congress of Refrigeration, held at Chicago, September 17 to October 1. Twenty-five foreign governments sent official delegates and ten others were represented unofficially. Argentine Republic, Austria, Germany, France, and Russia were each represented by several delegates, many of them cabinet officers. All were agreed that the art is in its infancy and that a tremendous future growth was inevitable.

Dr. Harvey W. Wiley, former Chief of the Bureau of Chemistry, U. S. Department of Agriculture, in a paper read before the congress stated that, "the three great problems which confront humanity today are food, labor and distribution." Increase in the price of food is not solely due to scarcity but because people are eating better foods, gold is relatively abundant and more and more people are flocking to the cities. The preservation of food and the distribution to the families in the congested cities is the crying need of the day. During the summer months many of our food products are permitted to go to waste because of a glutted market. As a result the supply during the winter months is limited and the prices almost prohibitive. With suitable methods of preservation the oversupply during the summer months may be conserved to meet the deficiency of winter.

Of the three methods of preservation, viz., refrigeration, sterilization and desiccation, not counting curing by pickling and smoking, preservation by refrigeration is the particular field of the mechanical engineer.

The popular aversion to cold storage products is fast becoming dissipated because of the tremendous strides made in recent years along this line of preservation. This popularizing of cold storage products is in a large measure due to the foresight of our own Government in establishing the Food Research Laboratory in connection with the Bureau of Chemistry. Here the various food products are carefully studied with a view of determining the best method of preservation and the producer is given the benefit of the investigations. Food prepared and stored in accordance with the recommendations of the Research Laboratory are wholesome and it is difficult in many instances to differentiate between the freshly prepared and the cold storage product. Take, for example, the proverbial cold storage chicken; the popular impression is that of a fowl of uncertain age, indifferently prepared, packed for an indefinite period in ice and foisted eventually upon a remonstrating public. As a matter of fact if it is prepared and stored according to Government recommendations, the process is as follows: the freshly killed fowl, age stipulated, is dry picked, cooled for 24 hours at 32 degrees F., frozen and stored at 10 degrees F. and is delivered to the consumer in a frozen state. If used immediately after thawing out the result is a quality as good, if not superior to the freshly killed bird. That these instructions are not generally followed is evidenced by the material furnished by the local market, but it is only a question of time when the cold storage warehouse will be looked upon as a blessing and not with suspicion.

The various food products require different methods of preparation and different storage temperatures and it is up to the engineer to devise economical means for effecting this result.

The demand for experienced refrigerating engineers is an increasing one, not only in our own country, but in practically every civilized country of the globe.

—*G. F. Gebhardt.*

Two years ago Mr. James Bryce, at that time British Ambassador in Washington, wrote an article in Chambers' Journal on *"The Secret of Influence."* In this study he deals especially with the great men who have appeared in history as leaders of their kind—Richelieu, Cromwell, George Washington or Bismarck, Luther, Rousseau, Tolstoi or Carlyle. His conclusions however would seem to benefit also the ordinary man and our daily experiences. No doubt, many engineers are mistaken in thinking that the secret of influencing other men and affairs lies only in the thorough *knowledge* of their profession. Without doubt this is the most necessary condition of success, yet other elements enter into the making of a personality fit to influence his fellowmen for good or for worse. What are these elements? (1st) Intellectual independence and initiative; (2d) tenacity of purpose; (3d) good judgment; (4th) sympathy.

When a man has reached a point of independent thinking and acquired the ability of organizing the result of experience and study into a coherent view, he may be sought by others in the capacity of a consulting engineer. As long as he depends chiefly upon textbook guidance or upon the advice and instruction of professors and superior officers in his business, he is confined to the limitations of his sources and authorities. To exert any decided influence within the domain of his professional activities, however, he must be able to point to new paths whether of method or of investigation. It takes courage to face difficulties and responsibilities, and it requires insight and foresight to take the initiative in any field of labor. Only the fearless are able to think and act independently.

In regard to tenacity of purpose, it is a well known truth that he who "sticks to his job" generally wins out. Many maxims have been written concerning this characteristic. "Never undertake what you do not expect to carry out;" "Never leave a job unfinished," etc. It is easy to see how a man without a set purpose, drifting with the opportunities and changes of the day, has no vigor or force to influence others.

Good judgment: Is it not a well known fact that more men lose their positions or their opportunities for lack of good judgment than for lack of professional knowledge? Tactless, disorderly, and careless characters will never be placed in

position of trust or of command. Sound judgment can be acquired only by long training, by careful observation of men and events, and by diligent study of human character. As the graduates of engineering schools will have under their direction men of different nationalities, often ignorant and uneducated, they will need all the resources of their own insight in order to deal justly and firmly with these inferior types of men. They will also need a good knowledge of human nature as well as of the play of different forces making for progress in our civilization, if they deal with the officers of a corporation or with their superiors in any business concern. In the effort of training their own judgment, sympathy with men and events will come them in good stead. By sympathy is meant that "practical imagination" which enables men to place themselves in the position of another and to look at the problems to be solved through his eyes and from his point of view. The inability to understand others as well as ourselves is generally the result of our lack of sympathy. It is easier to sympathize with people in misery than it is to sympathize with their joy of success. But unless we can do the latter also, we have not yet learned true sympathy. It is a pity that any engineering course is naturally such a strenuous affair that most of the time and strength of the student are taken up by the pursuit of his professional studies, leaving him little time or inclination for broadening the activities of his mind and heart. The ambition of every college student is, nevertheless, to become a leader of men, or to stand in the front rank of investigators and builders. To accomplish this ideal, he *must know how to influence others*, and this influence is for the most part *unconscious*, resulting naturally from the character and general attitude of a man. It behooves him, therefore, unceasingly to labor in the acquisition of such elements of power as will place him on the heights where his character may be taken for an example and where his word is heard as authoritative. Besides knowledge and experience, the secret of influence is *personality*: a personality of *independent thinking*, with a *steady purpose*, *good judgment*, and *ready sympathy*.

—*Louis C. Monin.*

ARMOUR INSTITUTE OF TECHNOLOGY BRANCH OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

At the last meeting of the year 1912-1913 of the Armour Institute branch of the American Society of Mechanical Engineers the following officers were elected:

President,	H. E. Erickson.
Vice-President,	E. Menke.
Secretary,	A. N. Koch.
Treasurer,	L. C. Meyer.

The year 1913-1914 was formally opened with the annual Society smoker on September 24, 1913. This afforded the incoming Juniors an opportunity of becoming acquainted with Seniors and members of the Faculty of the Mechanical Engineering Department.

The first regular meeting was held on October 16, 1913. The evening was devoted to a talk given by Mr. C. W. Naylor, Chief Engineer of Marshall Field & Company, on the power plant of that store. After discussing the plant in a general manner he described in detail the elevators, plumbing and refrigeration system from a practical point of view.

On November 5, 1913, Mr. Harold D. Gumpper, '14 presented a paper on "Fans and Blowers," and Mr. Ludwig Bunge, '15, presented a paper on "Safety Devices on Elevators." The home talent was thoroughly enjoyed by all present. Complements were extended to both Mr. Gumpper and Mr. Bunge on their willingness to talk and the manner in which each presented their subjects.

— *A. N. Koch.*

ARMOUR INSTITUTE OF TECHNOLOGY BRANCH OF THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

At the last meeting of the year 1912-1913 of the Armour Institute branch of the American Institute of Electrical Engineers the following officers were elected:

President,	E. L. Nelson.
Secretary,	T. C. Bolton.
Treasurer,	A. F. Schoembs.

The activities of the society were begun this year on October 8 with a smoker which was attended by the majority of the members of the Junior and Senior classes. Plans for the work of the coming year were thoroughly discussed. Professor Freeman gave a short talk on the aim of the student branch and the benefits to be derived from it. For the information of the Junior members, the character of the Institute Proceedings and their value to the student was discussed by Professor Nichols. The date of meeting was fixed as the second and fourth Wednesdays of each month. The enthusiasm shown on this occasion argues well for the success of the organization during the coming year.

The first regular meeting took place on October 22 in Chapin Hall. Papers on the application of direct and alternating currents in railway signaling apparatus were presented by C. L. Wetzel, '14, and M. V. Stecher, '14. These men have both had some experience in railway work and were able to present the subject from a practical as well as a theoretical standpoint. A lively discussion followed.

The midwinter banquet will be held as usual during the month of December.

—*T. C. Bolton.*

CIVIL ENGINEERING SOCIETY.

At the last meeting of the year 1912-1913 of the Civil Engineering Society the following officers were elected:

President,	H. F. Smith.
Vice-President.	C. A. Dean.
Treasurer,	J. Pomerene.
Recording Secretary,	E. J. Zack.
Corresponding Secretary,	M. J. Fleming.

The first meeting of the society for the year 1913-1914 was held in the Engineering rooms on Tuesday, October 6. Professor Phillips was the first speaker of the evening, and gave the officers some good advice on different matters pertaining to the society. Professors Wells, Armstrong, Dean and Penn followed with short but interesting talks. Professor Penn gave the Seniors some hints on thesis work, and at the request of President Smith, Professor Phillips also gave his ideas and suggestions on the same topic.

On October 21 the Junior candidates for membership in the society were initiated. Each candidate was asked to perform various "stunts" which afforded much amusement. After this came the "smokes" and "eats." The evening was certainly a very enjoyable one.

On November 4 the first lecture of the society was held in the Engineering rooms. Mr. Samuel Klein of the class of '06 gave a very interesting paper on "Concrete Design and Construction." The officers have arranged for a number of other papers which should prove very interesting.

The Sophomore Civils are cordially invited to attend the meetings of the society. It is hoped that they will take advantage of the offer and attend regularly. By this means they will get a good insight into the work of the society and will know what to expect when they become eligible for membership as Juniors. The society also extends the same hearty welcome to the alumni, and it is hoped that they will attend and become acquainted with the present members.

—*W. Ehrlich.*

THE SENIOR CHEMICAL SOCIETY.

At the last meeting in the spring the following officers were elected:

President,	Clark C. Heritage.
Vice-President,	Joseph T. Zavertnik, Jr.
Secretary,	Frank W. Hook.
Treasurer,	Glen C. Carnahan.

From the active interest thus far shown by the members of the society, this promises to be the best year which the society has ever experienced.

Recognizing the advantages to the students of having discussions on interesting topics, the policy of the society has been changed to a large extent and instead of having monthly banquets, as heretofore, the members meet every two weeks and enjoy talks by members of the faculty and society.

The first meeting was called by President Heritage on September 30 and at the time a Constitution Committee was appointed to draw up a Constitution to take the place

of one long extinct. A Program Committee was also elected and to these men fall the responsibility of keeping up the interest in the society by preparing interesting programs.

The next meeting was held October 1 when the Constitution was ratified and the policy of the society was further outlined by suggestions from various members.

On October 29 the first regular program was given and all were well entertained by the following talks:

"Paper-Making," by E. W. McMullen; "An Experimental Electrolytic Potassium Chlorate Plant," by C. C. Heritage.

It is hoped that as the year progresses the interest will become more intense and that the members will all be benefited by their efforts.

—*F. W. Hook.*

THE ATELIER.

At the first meeting of the Atelier of the Architectual Department, the following officers were elected:

Massier,	Fred D. Farrar.
Secretary,	B. K. Gibson.
Treasurer,	G. S. Barber.
Social Representative,	C. E. Wolfley.
Purchasing Agent,	C. E. Wolfley.
Fulcrum Representative,	J. L. Shane.

The other members of the Social Committee are I. Swanson from the Junior Class and B. S. Roos from the Sophomore Class.

The Juniors elected E.A. Schiffers for Massier, A. G. Stark for Treasurer, and E. F. Schreiber for Purchasing Agent.

The Sophomores elected C. C. Porter for Massier, and H. L. Wallbercht for Treasurer.

The Senior problem, "An Aeroplane Establishment," has been completed and the drawings are now on exhibit in the exhibition room at the Art Institute. The Seniors are now busy on their new problem, "A Modern Skyscraper Hotel."

Architect Nimmons was present at the criticism of the Junior problem, "A Storage Warehouse," at which he gave

a talk on the merits of the different designs and assisted in judging the work. The new Junior problem is "A Bank Building."

The present problem of the Sophomore class is "A Park Pavillion." The completed problem of the class, "A Frontispiece," is now on exhibit.

Along social lines the Atelier has been far from idle. The Hallowe'en dance at Blackstone Hall in the Art Institute was a decided success. The novel features furnished by the Freshmen and the culinary department of the Institute were accepted with enthusiasm by the dancers who tangoed and one-stepped among the masterpieces of art and sculpture to the music of a large orchestra. Several alumni faces were noticed at this event.

Another affair that brought out the alumni was the first smoker of the year. The smoker was followed by a banquet, which was the occasion for several brilliant talks by alumni and undergraduates.

The next smoker, which will soon be announced, will be preceded by the initiation of the Freshmen.

The Atelier has shown more real spirit this year, both in work and play, than it ever has in former years.

—*B. K. Gibson.*

ALUMNI NOTES

ANNOUNCEMENT EXTRAORDINARY

The Board of Managers of the Alumni Association of the Armour Institute of Technology take pleasure in announcing that an arrangement has been made with this publication by which members of the Alumni Association in good standing will receive yearly subscriptions to the Armour Engineer without extra cost, i. e., the payment of one dollar in advance for the annual dues will also include all issues of this magazine for the current year.

The purpose of this arrangement is two-fold: first, to increase the usefulness of the Association both to its members and the Institute by providing a medium through which current matters of interest, technical, social and personal, may be set forth; second, to increase the subscription list of the Armour Engineer, and in this way enable its management to carry out plans for enlarging, and, even improving, its already high standing among engineering journals.

It requires the co-operation of all Armour graduates by becoming active members of the Association to secure the successful culmination of this arrangement.

The alumni members will not only receive one of the best technical journals and a membership in the Association for the usual cost of one, but will also be given an opportunity to keep in close touch with one another.

This latter fact should not be underestimated and is one of the potential reasons why the Board of Managers inaugurated this movement.

Formerly, members who lived in and around Chicago could always attend a meeting of the Association with its natural benefits, but those located at distant points were never informed of the affairs of the Institute and the doings of their former class-mates; and, as a result, lost some of the Armour spirit.

We now propose to keep alive this spirit as recently resurrected and to keep these pages full of interesting matter. DO YOUR PART NOW. Send to the Editor any bit of interesting information about yourself or fellow alumni, and send *one dollar dues* (if you are not already a member), together with one dollar extra for reinstatement fee to Mr. F. G. Heuchling, 1310 Glenlake Ave., Chicago, Ill.

Remember that we are sending broadcast to graduates of the Institute free copies of this number only in order to announce our plan.

A $2 bill will reinstate you as a member of the Association and pay the current dues to June, 1914.

If you are in doubt as to how you stand in this regard, please refer to the enclosed list containing the names of all members in good standing. We wish also to call the attention of those members who have not as yet paid their advance dues to June, 1914, that they should forward the same to the Treasurer at once if they wish additional copies of the magazine.

You can show your interest also by offering articles of a technical nature to the Editor of the magazine. They must be written by yourself from personal experience. Thus you may add to your own prestige and also to that of *The Armour Engineer.*

All notices and publicity matters of the Alumni Association will in the future appear in these pages.

Publication Committee Armour Alumni Association:

F. M. deBeers, Chairman.
H. W. Nichols.
H. W. Clausen.

ANNUAL MID-WINTER BANQUET.

The regular Mid-winter Meeting and *Banquet* of the Alumni Association will be held at the Hotel LaSalle, at 6 P. M., on Saturday evening, December 20th, 1913. Tickets, $2 per plate.

A program of unusual interest has been arranged by the Master of Ceremonies, the most important of which is an illustrated lecture on "The Chicago Plan," by Mr. Chas. H. Wacker, Chairman of the Chicago Plan Commission.

We consider ourselves much flattered in securing Mr. Wacker to address us. As you all know, it is the life-work and highest ambition of Mr. Wacker to arouse the public of Chicago to a realization of its natural beauty and opportunities for an orderly improvement. Not only will we be advised of Chicago's needs, but also in contrast, as it were, will we be shown the splendor of many European cities, which have not the natural conditions for beautification that Chicago has.

This subject is now foremost in the minds of Chicago's citizens in connection with some of the larger projects which are now pending; such as, the Terminal Problem of the Railroads, etc.

Besides the lecture by Mr. Wacker, there will be music and song—such as you have seldom heard. For information concerning it ask the Master of Ceremonies.

As for food, it suffices to say that it will be the best obtainable—fit for the palate of the most fastidious. We know this, because we have seen the bill of fare. You would agree with us if you had.

The Combination of:

A beautiful banquet hall—perfect food, and plenty of it—good music—good songs—good smokes—good college spirit—excellent illustrated lecture on the question of the hour by a distinguished citizen is not to be easily resisted or forgotten. The man who could withstand such a temptation is not actuated by human emotions—that's all.

Remember the date: December 20, 1913. Keep it open. SAVE TWO DOLLARS, and BLOW YOURSELF for a ROYAL GOOD TIME!

The following is a list of those present at the Spring Banquet of the Alumni Association on May 24, 1913:

Alschuler, A. S.	Beerbaum, A. J.
Anderson, A. H.	Beifeld, H. A.
Babcock, F.	Bernhard, F. H.
Baer, W. J.	Brehmer, A. H.
Banning, T. A.	Bohlander, H. A.
Banta, J. S.	Bornstein, H.
Bear, Wm. P.	Brubaker, W. C.
Beck, C. E.	Buell, C. S.
deBeers, F. M.	Burge, G. C.

Busse, C. F.
Carroll, E. J.
Carr, A. L.
Chan, Y. H.
Chandler, J. G.
Chapman, A. B.
Clausen, H. W.
Cleaver, T. G.
Collins, C. W.
Croskey, P.
Dean, S.
Dean, W. T.
Douthitt, M. J.
Dowdell, C. O.
Downton, P.
Dreffein, C. G.
Dreffein, H.
Durr, H. A.
Ellett, E. H.
Erickson, O. R.
Eustice, A. L.
Ferrenz, L. J.
Flood, W. H.
Freeman, E. H.
Goldsmith, F. R.
Goldstein, J.
Graham, F. A.
Goodhue, A. H.
Grassby, G. A.
Greifenhagen, E. O.
Heitner, W. O.
Hess, A. L.
Heuchling, F. G.
Hill, W. E.
Hiller, E. F.
Hindert, E. G.
Holcomb, C. S.
Holden, E. C.
Holtman, D. F.
Jacobson, J. H.
James, G. B.
James, S. V.
Johnson, R. W.
Jones, C. I.
Kellner, O. K.
Kiley, L. D.
Konicek, F., Jr.
Lang, W. H.
Leichenko, P. M.
Lewis, R. L.
Libbey, E. S.
Lindberg, F. A.
Loewenberg, M. L.
Longnecker, C. S.
McCague, J. A.
McCune, S. W.
Mahler, E. E.
Marienthal, O. B.
Matchett, J.
Moreton, D. P.
Morrison, R.
Nachman, H. L.
Nichols, H. W.
Nicholson, V.
Neufeld, R.
Newhouse, A. M.
Paradise, L. A.
Pavey, W. B.
Pearce, R. P.
Perry, R. V.
Petty, E. W.
Porter, L. I.
Prescott, O. R.
Putt, F. A.
Rice, R. H.
Roesch, Dan'l.
Robinson, R. H.
Roller, L. H.

Rosenthal, H.
Sampson, C. C.
Sanford, L. A.
Schmidt, E. J.
Schroeder, C. P.
Shimizu, H. S.
Sieck, H.
Sieck, W.
da Silva, C. J.
Simmons, L. E.
Sklovsky, M.
Spalding, R. S.
Spitzglass, J. M.
Stadeker, G. I.
Stanton, G. C.
Strale, N. W.
Strube, H. L.
Swift, J. B.
Taussig, W. S.
Terry, O. N.
Turnbull, I. J.
Wagner, A.
Walbridge, J. T.
Whitaker, O. A.
Wilsey, G. H.
Woldenberg, M.
Wuehrman, W. G.
Aeberly, J. J.
Arenberg, A. L.
Arnold, C. H.
Badger, O. C.
Bradford, J. D.
Brown, P. K.
Burley, E. R., Jr.
Cooper, H.
Cramer, A. C.
Curtis, M.
Drozeski, D. A.
Ehrman, J. S.
Fischel, R. E.
Fryburg, W. F.
Gugis, K.
Hayes, J. J.
Jarvis, B. K.
Johnson, P. O. E.
Kehr, C. F.
Knaus, P. J.
Koch, R. J.
Kuehn, H. R.
Larson, C. M.
Lantz, W. H.
Lill, A. C.
Lucas, J. T.
Mann, W. C.
Marx, W. L.
Newman, I.
Opper, G. L.
Pirrie, P. G.
Robertson, A. F.
Schmieman, O.
Schuette, A. J.
Schular, C. R.
Semerak, A. W.
Spencer, C. H., Jr.
Stewart, J. L.
Tong, M. I.
Wald, M. D.
Waters, H. S.

The success of any organization such as the Alumni Association depends largely upon the soundness of its financial resources. This is more especially true when the functions of the

organization are to be extended as is the case now, under the co-operative agreement between the Association and the Armour Engineer. This fact may best be emphasized by the statement that henceforth by far the greater part of the dues paid by the members will have to be used to defray the expenses incurred by the arrangement with the Armour Engineer.

The following brief statement is presented in order to show the attempts which have been made to make the available funds of the Association adequate to meet the demands which will be made upon it.

The present Treasurer was appointed by the Board of Managers in October, 1912, to fill a vacancy caused by the resignation of the Treasurer elected at the spring meeting of 1912. At the time of this appointment the total funds in the treasury amounted to $1.83.

Upon taking over the new work the first step undertaken was to examine the available records in order to determine how many graduates of the Institute were fully paid up in their dues. Then followed a campaign for the purpose of increasing the membership and collecting unpaid dues.

On March 20, 1913, a written individual statement was mailed to each graduate in arrears. These statements were over 600 in number and considerable clerical work was involved in their preparation. The result of these efforts were very gratifying. Replies were received from graduates located in nearly every state in the Union, Panama, Mexico, Canada, Hawaii and Japan.

On March 27, 1913, the Treasurer submitted a progress report to the Board of Managers in which he pointed out that if the Alumni Association was to keep in touch with the graduates in remote corners of the earth, the "touch" would have to be something in addition to the financial one. It could hardly be expected that these isolated patriots would continue to donate annual dues to the Association if the only mark of appreciation which they received in return was a receipt for payment. This report suggested that a co-operative plan be established between the Association and the Armour Engineer.

After several months of conference this plan was finally consummated and is more fully announced on other pages of this issue. There is no chance of its proving a failure if you, dear readers, and every one of you, will assist in the work of spreading the cause of Armour into the farthest points of the globe.

It might be well to state that during the period from March 20, 1913, to the present time, a space of about seven months, the paid-up membership was more than doubled. In actual figures, the present paid-up membership is 213 per cent of what it was on March 30, 1913. In addition to this, signed pledges were obtained for more than forty members of the Class of 1913 who attended the spring banquet on May 24, 1913, indicating their intention to join the Association before January 1, 1914.

Space does not permit of including a financial statement of the receipts and expenditures for the last school year. This statement was issued to those who attended the spring meeting at the Institute on May 24, 1913. Copies are still available, and will be cheerfully sent to anyone on application as long as the supply lasts.

Mail addressed to the following graduates at either their home address or place of business, as given in the Institute Bulletin for May 1913, has been returned undelivered.

Any one who has any information as to their location will confer a great favor by communicating to

Mr. F. G. Heuchling, Treasurer, 1310 Glen Lake avenue, or to

Mr. H. W. Nichols, Corresponding Secretary, Armour Institute of Technology.

Frank Albert Coy, I '04.

Augustine Davis, Jr., II '06.

Adam Albert Dittmar, I '08.

Alfred A. Ebert, I '09 .

C. A. Ecklund, I '09.

Norman L. Edson, II '06.

Carl Heim, III '09.

Rolland M. Heskett, III '02.

Balthasar Hoffman, Jr., IV '07.
Bertram G. Jamieson, III '97.
Clarence Ira Jones, I '05.
Albert Kaempfer, III '03.
Edward F. Kappes, III '98.
George William Kuhn, III '06.
Joseph D. Livermore, V '10.
Robert Cloughan Martin, III '00.
Edw. McBurney, Jr., II '05.
Eugene Daniel Meyer, III '06.
Grover John Meyer, I '08.
Ralph D. Morrison, III '06.
Elmer H. Olsen, III '99.
Arnold Pacyna, IV '08.
Francis Tyler Pierce, I '06.
H. Boyd Rawson, III '03.
George Ben Robinson, I '03.
Irwin Herbert Schram, I '08.
Joseph Nicholaus Schumacher, IV '06.
George W. Smith, III '06.
Monroe Adney Smith, I '10.
Charles Rossiter Snowden, III '05.
Frank Leonard Thomson, VI '08.
Marinus Vanderkloot, IV '09.
James McCombie Watt, II '04.
Fred Boston Whitney, I '05.
George F. Wolters, V '08.
Louis T. Zeisler, III '10.

ALUMNI SCHOLARSHIP LOAN FUND.

The Alumni Association is extremely desirous of being a real benefit to the Institute and to the studenty-body, and in accordance with this desire an amendment was made to the constitution in December, 1910, which provides for life membership in the Alumni Association upon payment of twenty dollars.

The fund so accruing is to be loaned to students in need of assistance, preferably upper classmen, so that they may complete their courses.

The amounts loaned are limited to $150.00, payable two years after graduation, and bearing 5 per cent interest, the interest accruing being given over to the Alumni Association in lieu of the yearly dues of the subscribers to the Scholarship Fund.

No security is required from borrowers, but an investigation is made into their needs, reliability and responsibility.

This investigation is made by the Scholarship Loan Fund Committee of the Alumni Association working with the Deans of the Institute. This Committee includes one member connected with and at the Institute, and is as follows:

E. F. Hiller, Chairman, 4533 Ellis avenue.

H .W. Nichols, Armour Institute of Technology.

F. A. Lindberg, care of Gardner & Lindberg, Marquette Bldg.

Applications to one of the Committee members, or to the Deans, are invited, and will receive attention in so far as the available funds will allow.

The statistics of the fund, at present time, are as follows:

Number of life members	29
Total amount of funds	$580
Amount loaned	$485
Balance available for loans	$ 95
The first loan was made in February	1911
The total number of students receiving loans	11
The total amount loaned to date	$725
Range of loans, $20 to	$125
Average amount of loans	$ 66

Respectfully submitted,

E. F. Hiller. Chairman.

THE SPRING MEETING OF 1913.

The managers of the Alumni Association of Armour Institute of Technology, in considering the nature and place of the meeting scheduled for the Spring of 1913, gave heed to the provisions of the Constitution which sets forth as objects of the Association: (1) the promotion of goodfellowship, and (2) maintenance of interest in affairs at the Institute. It was agreed that a more prolonged and less formal gathering which

would give the graduates a chance to mix more readily than at a standard banquet would serve towards the furtherance of the first object. At the same time it seemed plain that a visit to Armour would be the most effective way of getting into touch with Institute developments, plans, and activities. The natural conclusion was: "Let's meet at 33rd and Armour."

Accordingly a crowd assembled on Ogden Field about 3 o'clock Saturday afternoon, May 24, 1913, and watched the Alumni "Old Stars" beat the regular Tech' nine in ten innings, 4 to 3.

After the game most of the crowd surged over to the new laboratory building on Dearborn Street and jammed in to see "Dan" Roesch burst a timber 8x8-inch by 10 feet long in the new 400,000 pound testing machine. Everybody guessed at the ultimate strength and, as announed at the banquet, D. Holtman, '12, won the prize with an estimate of 250,000 pounds, while W. T. Dean got the booby by guessing 42,900. The actual strength was 249,275.

About 6 o'clock the alumni began to gather in the lobby of the main building in such numbers that the Chairman of the Supper Committee and the caterer began to get badly flustrated and the Treasurer swore in a half dozen deputies to take the money. Before all the tickets had been sold the crowd (most of them sweet boy graduates with complimentary cards) ran over the doorman and filled the library. A heartbroken committee made decidedly make-shift provisions for a second table and a heartbroken Treasurer refunded money to many alumni too hungry to wait. There were 184 plates laid (which broke all past records by at least 75 plates.

Dr. Gunsaulus said grace and added a word of welcome. He said the meeting differed from a church meeting in that many more attended than promised to attend while in gatherings of the latter type many more promised to come than actually appeared at the time appointed. Dr. Gunsaulus then left us (and his soup).

After the supper had been served and pretty well disposed of, Chairman Rice of the Booster Committee presented the deBeers loving cup to the Class of '02 (care of Anderson) as it had the greatest percentage of resident members in attendance. President Greifenhagen then spoke in welcome to

the graduating class of 1913 and thanked the Institute Council and the faculty for their co-operation in working out the reunion plans. President Burley of the class of 1913 replied for his class. Professor Monin next addressed the meeting in a rousing speech overflowing with enthusiasm and kindliness and uttered in his usual hearty and sincere manner. He was greeted and thanked by prolonged applause and cheers.

The famous Armour Quartet contributed a few jolly songs and W. G. Smith of the faculty followed with a solo. These contributions from home talent were thoroughly appreciated.

Comic songs and clever monologs by Chris Lane followed on the program and served their part in "enlivening the occasion."

Next everybody mounted chairs and tables and grouped like an audience about a cock-pit to watch "Herbert the Prestidigator" prestidigitate. Fish and hens were produced from thin air, and chains and rings were slipped into the fourth dimension. Everyone was properly impressed.

Ernest McCullough, all around engineer, spoke briefly and practically on the "Engineers' Fight," referring to the engineers' fight for a job and for adequate compensation and recognition. The lateness of the hour prevented the free-for-all Alumni discussion on the subject which had been planned.

The meeting wound up with a snappy business session at which officers reported a year of progress. It was announced that the treasury was in fine health and that the membership had been substantially increased—thanks to the efficiency of Treasurer Heuchling. Chairman Hiller of the Scholarship Loan Fund Committee made a plea for more life members and was backed up by the President with the result that eight new memberships were pledged. The proposed arrangement with *The Armour Engineer*, which has now been consummated, was referred to and seemed to meet unanimous approval.

The ticket offered by the Nominating Committee was elected and two additional members of the Board of Managers were chosen to fill unexpired terms. The personnel of the Board of Managers at adjournment stood as follows:

BOARD OF MANAGERS ALUMNI ASSOCIATION ARMOUR INSTITUTE OF TECHNOLOGY, 1913-1914.

President	Henry W. Clausen, '04.
Vice-President	Thomas A. Banning, '07.
Corresponding Secretary	Harold W. Nichols, '08.
Recording Secretary	C. E. Beck, '11.
Treasurer	F. G. Heuchling, '07.
Master of Ceremonies	W. B. Pavey, '99.
	Harold A. Durr, '05.
Managers to 1916	Fritz A. Lindberg, '01.
	E. O. Greifenhagen, '06.
	F. M. deBeers, '05.
Managers to 1915	E. F. Hiller, '06.
	J. B. Swift, '01.
	A. E. Alschuler, '99.
Managers to 1914	W. G. Wuehrman, '08.
	E. F. Gillette, '06.

The Board of Managers of the Alumni Association of Armour Institute of Technology for the year 1912-1913 devoted considerable time to determining Association policies, especially as relating to finance and in considering ways and means of carrying out the mandates of the constitution and the objects of the Association and through discussions references to precedent, and actual experience arrived at valuable conclusions which they decided to record for the use of the future Boards.

These recommendtions should interest the entire membership and are printed here for that reason:

CODE OF RECOMMENDATIONS

Prepared by the 1912-1913 Board of Managers of the Alumni Association of Armour Institute of Technology for the use of future Boards.

For the purpose of assisting future Boards of Managers and officers of the Alumni Association of Armour Institute of Technology this Board has prepared, and transmits herewith, the following code of recommendations, outlining methods

of procedure and policies which they believe to be the best in the light of their experience and the experience which past Boards have recorded.

Section 1. *Aims of the Association:* As set forth in the constitution, it is the object of the Association to promote fellowship and goodwill among its members and to keep alive their interest in affairs of Armour Institute of Technology. We urge that these objects be kept constantly before the Board in its work and that for their accomplishment every effort be made (1) to increase the membership and to make membership worth while, (2) to make the meetings of the Association as enjoyable as possible for those who attend and to make every effort to obtain a large attendance at such meetings, and (3) to keep in touch with affairs at the Institute by frequent visits, by frequent invitations to the faculty to attend the Associaion meetings, by support of Institute publications and activities, and by including whenever possible one or more graduates resident at the Institute in the personnel of the Board.

Section 2. *Finances:* It is recommended that the following principles be observed in ordering the finances of the Association, namely:

a. That no expenses be incurred which cannot be met by the funds on hand at the time the expenditure is made.

b. That dues collected in advance be not extended prior to the expiration of the year for which they are paid.

c. That no dues be expended for any purposes which do not benefit the entire membership of the Association.

d. That banquets and entertainments be made self-supporting; that is, that sufficient charge for tickets be made to defray all expenses (with the exception of announcements) without depending on dues therefor.

e. That expense accounts which may be submitted by officers or committees be disapproved unless previous authority for the expenditures was obtained.

f. That the practice of paying the plate fee for the graduating class invited to the spring meeting be discontinued.

Section 3. *Newly Elected Officers:* It is recommended that newly elected officers and members of the Board read carefully the constitution and by-laws of the Association, the minutes of all meetings of the Board held during the year

previous, and this code of recommendations, in order that they may promptly become acquainted with the restrictions under which they will work, the duties of their respective officers, the various policies adopted by past Boards, and the various activities which the Association may have under way.

Section 4. *President:* It is recommended that the President, immediately upon his election (1) obtain from the outgoing officers such papers, documents, and records as they may have in their possession pertaining to the business of the Association and that he transmit such papers, documents ,and records to the respective newly elected officers, (2) that he obtain a complete list of the names, addresses, and telephone numbers of all members of the new Board and transmit a copy thereof to all members of the new Board, (3) that he request all new officers to report at the first meeting in regard to the condition in which their predecessors in office have left their records, (4) that he call a meeting of the new Board before the thirtieth day of September following the annual spring election in order that the membership may become acquainted and that plans for the year's work may be laid. It is recommended that the President call a meeting of the Board at least once in every two months throughout his term and prior to such meetings prepare for presentation all business which should come before the Board. The President, by virtue of his office, is largely responsible for the work of the Association and the progress it makes during his term toward the accomplishment of its objects and he should bear this constantly in mind.

Section 5. *Vice-President:* Established custom has made the Vice-President ex-officio permanent chairman of the "Booster Committee," and we recommend that this practice be continued. The objects of the Booster Committee shall be to increase the membership of the Association and to bring out the largest possible attendance at all meetings. As chairman, the Vice-President shall, at least two months before the mid-winter meeting, obtain lists of members of past Booster Committees and obtain from the Board of Managers the reappointment of such committees or substitutes therefor which he may recommend. The Booster Committee shall contain representatives from each class in the approximate ratio of one for each twenty-five members. The chairman shall instruct all

members of his committee in regard to the nature of their duties and the best methods of accomplishing the results desired, and shall plan a campaign to guide them in their work. The Vice-President should strive throughout his term to increase the membership of the organization and initiate campaigns with that end in view.

Section 6. *Corresponding Secretary:* The Corresponding Secretary shall, in keeping a roster of the membership of the Association in accordance with the constitution, maintain a 3x5 card index made up of "roster cards" filled out by members in reply to the notice of the semi-annual meeting. Whenever a new card is returned from a member it shall be substituted for the old card. It is recommended that the form of card used in the spring of 1913, or an improvement thereon, be adopted. The Corresponding Secretary's records should be compared with the records of the Institute from time to time. The names of members whose correct addresses are lacking or for whom complete data is not on hand should be presented to the membership at semi-annual meetings and assistance requested. Such names shall also be advertised in *The Armour Engineer.* The Corresponding Secretary shall consult with the President, Master of Ceremonies, and chairman of the Booster Committee before sending out notices of meetings. The Corresponding Secretary shall assist the Treasurer in preparing lists of members.

Section 7. *Recording Secretary:* The Recording Secretary shall keep the minutes of the meetings of the Association and of the Board of Managers and shall provide each member of the Board of Managers with a copy of such minutes within one week after each meeting. He shall note the names of members present and members absent at each meeting. He shall keep on hand a number of copies of this code of recommendations; he shall keep an approved copy of the minutes of all meetings of the Board in a durable loose leaf book; he shall maintain a record of the names and classes and terms of all past officers of the Association, a record of the numbers of graduates of the Institute for each year, the number who joined the Association at the time of their graduation, and the present number from each class who are active members; he shall deposit in the vaults of the Institute copies of all the announcements,

programs, and minutes of meetings of the Association and copies of the minutes of all meetings of the Board of Managers and he shall complete all such files for past years if he finds them incomplete.

Section 8. *Treasurer:* The way in which the duties of the office of Treasurer are handled will have a marked effect on the success of the Association. The following recommendations are made in regard to the procedure to be followed by the Treasurer in carrying on his work:

a. He shall keep an "Accounts Receivable" ledger in which he shall maintain an account for each individual member of the Association. Entries in this ledger shall be made to indicate clearly the purpose of payment, whether for initiation fee, reinstatement fee, dues, or banquet ticket.

b. He shall keep a general ledger in which he shall indicate all the receipts and expenditures of the Association, stating specifically in each case the source for which moneys are received and the purposes for which moneys are expended.

c. He shall send a statement to each member in arrears during the six months following his election as Treasurer, and at least one follow-up statement in case the payment is not made. He shall send postal card receipts for payments.

d. He shall report to the Board of Managers at its meeting just preceding the two semi-annual meetings of the Association and in such report shall give a statement of receipts and expenditures during the last half year and the present condition of the treasury, and shall present a list of life members, members paid up, and members in arrears.

e. He shall arrange for the assistance of one or more members at the time of the semi-annual meetings of the Association and at the time of such meetings shall have on hand a record of members in arrears and shall be prepared to collect dues payable from members at the time they apply for tickets.

Section 9. *Master of Ceremonies:* The Master of Ceremonies shall carefully familiarize himself with the duties imposed upon upon him by the constitution and shall indicate to the Board of Managers at least two months prior to each semi-annual meeting of the Association whether or not he is fully prepared to assume responsibility for the making of arrangements for, and the conduct of, such meetings.

Section 10. *Board of Managers:* The Board of Managers shall through the President, request the resignation of any member who shall fail to attend three consecutive meetings, regardless of the reasons given for such absences.

Section 11. *Sholarship Fund Committee:* New Members of the Scholarship Fund Committee shall preferably be chosen from Managers to hold office for a three-year term and should be reappointed from year to year until the expiration of their term as Manager. At least one member of this committee shall be resident at the Institute, if there be such resident on the Board. The Chairman of the Scholarship Fund Committee shall carry on an earnest campaign to increase the number of life members. A large number of life-members means financial peace and the maximum personal interest.

Section 12. *Auditing Committee:* The Auditing Committee shall be made up as far as possible from among past Presidents on the Board of Managers.

Section 13. *Publications Committee:* It is recommended that the Board of Managers appoint a Publications Committee to be made up of one member of the Board not an officer, the President, and the Corresponding Secretary ex-officio, such committee to have immediate charge of relations with the Institute publications and of all publicity work of the Association.

Section 14. *Nominating Committee:* It is recommended that the Board of Managers appoint a Publications Committee to Nominating Committee at the time of its appointment, namely:

a. That no alumnus be nominated for office who is not qualified by his personality, experience, nature of his business, place of residence, etc., to perform the duties of the position and who has not signified his full and free consent to the nomination, and expressed his intention to give ample time to the demands of the work.

b. That the Corresponding Secretary be chosen from among the graduates resident at the Institute; that the outgoing President be nominated for a place on the Board of Managers; and that strikingly faithful and efficient service on the part of an outgoing officer be recognized by renomination for the same office or for some other place upon the Board.

Respectfully submitted by the Board of Managers of the Alumni Association of Armour Institute of Technology for 1912-1913.

—per E. O. Greifenhagen, President.

In Memoriam

Professor A. J. Frith, of the Institute died suddenly Nove-ber 10, 1913, of acute dilation of the heart. His son was killed by an automobile last spring, and he had apparently never completely recovered from the shock. The body was taken to St. Louis for burial.

PERSONALS.

G. H. Wilsey, '08, is in Cleveland, Ohio, supervising the construction of a Burnham project in which he has been interested.

T. W. Simpson is Efficiency Manager for The Hot Point Electric Company, Chicago. He reports the recent arrival of a son.

V. Pagliaralo is in the research laboratory of the Kellog Switchboard and Supply Company.

A. C. Lohse, '11, has been appointed Works Engineer of The Whitman Barns Manufacturing Company, Chicago, Ill.

W. O. Heitner, '11, was married September 20, 1913, to Miss Lillian Reinhardt of Longwood, after a four years' romance.

Mr. M. L. Thompson, '08, Architect, was married to Miss Elsie Earl, at LaGrange, Ill., on October 30, 1913. Miss Earl is a graduate of the Art Institute. Mr. and Mrs. Thompson will be at home in Muscatine, Ia., after December 1, 1913.

Walter G. Leininger, '06, was certified by the Civil Service Commission to the position of Superintendent of Streets of the City of Chicago.

Myron B. Reynolds, '06, Civil Engineer, was certified by the Civil Service Commission to the position of Engineer of Water Works Design, Bureau of Engineering, City of Chicago.

A daughter was born to F. G. Heuchling, '07, Chemical Engineer, on June 20, 1913.

Edwin O. Greifenhagen, '06, Civil Engineer, resigned the position of Superintendent of Employment of the South Park Commissioners during the past summer. We are sure that the public has lost an able servant in this case. This is a splendid example of how petty politics will sometimes drive a good man to elimination, rather than submit to annoyances.

Harry A. Hart, '04, Civil Engineer, died during the past year in Chicago. We do not know the exact date nor the circumstances surrounding his death, and consequently are unable to give any details.

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Owner—The student body of the College of Engineering, Armour Institute of Technology, Chicago, Illinois.

(Signed) F. W. Hook.
Business Manager.

Sworn to and subscribed before me this 24th day of November, 1913.

Julia Beveridge
Notary Public.

My commission expires Jan. 8, 1914.

The Armour Engineer

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The Armour Engineer

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INDUSTRIAL GASES.

BY C. C. HOTCHKISS.*

The subject of "Industrial Gases," dealing with methods of manufacture, properties, production and uses, covers such an extremely broad field that in the present article only a brief consideration of the more commonly known gases will be given.

At the outset it would be well to bear in mind that the essential value of practically all industrial fuel gases may ultimately be reduced to one or all of the following three elements: carbon, hydrogen and oxygen. In other words, combinations of these elements in different proportions yield the various industrial gases which not only enter so largely into certain extensive manufacturing processes, but also play such an important part in our every day life. For example, one part of carbon in combination with four parts of hydrogen yields, almost entirely, that highly useful and important product, natural gas; two parts of carbon and two parts of hydrogen gives the well-known acetylene gas. We are thus led to wonder at the ability and resourcefulness of the modern chemist who is able to combine these few elements in almost any proportion desired to obtain the gas he seeks.

Industrial processes for the production of the ordinary gases may roughly be classified as follows: Gas formed from solid materials, as coal gas, water gas, producer gas, acetylene, blast-furnace gas, etc.; gas formed from fluid materials, as oil gases, hydrogen, oxygen, etc. Natural gas, as its name implies, is collected directly in its native state as it issues from the earth, often in connection with petroleum wells.

In order that some comprehension may be had of the enormous production of the principal industrial gases in the

*Class of 1906. Assistant Superintendent, Testing Laboratory, Peoples Gas Light and Coke Co., Chicago, Illinois.

United States alone, the following table from the Government Census Bureau is here shown:

Production of Artificial Gas in Thousands of Cubic Feet.

Kind of gas—	Year 1909.	Year 1904.	Per cent increase or decrease.
Straight coal	19,985,253	12,693,034	57
Straight water	1,726,082	715,550	141
Carburetted water	79,418,486	54,687,418	45
Mixed coal and water	40,775,283	40,980,414	—1
Oil	8,688,860	3,441,352	152
Acetylene	25,186	7,881	220
All others	216,643	24,330	790
Total production	150,835,793	112,549,979	34

The above statistics do not include gas made in coke and other establishments producing gas as a by-product, nor producer and blast-furnace gas for power and furnace purposes made by establishments in which they were consumed.

The amount of natural gas consumed in the United States in the year 1909 was 480,706,174 cubic feet, as compared with 509,155,309 cubic feet in 1910, or an increase of nearly 6 per cent. For the year 1909 it may be seen that the amount of natural gas consumed was about six times the total amount of carburetted water gas used the same year. In spite of this fact we read that during the year 1911 there was a waste of natural gas, due to carelessness and inefficient methods, larger than the total output of artificial gas during the same period in all the cities and towns of the United States. The same year, 1911, in producing 500,000,000 tons of coal, there was wasted, or left underground in such condition that it probably will not be recovered in the future, 250,000,000 tons of coal.

Before entering into a discussion of some of the more common industrial gases, a short sketch will be given of the early history of the industrial gas probably most familiar to all, namely, "city gas," or coal and carburreted water gas.

In tracing the early history of coal gas it is interesting to note that there are many instances on record, particularly in ancient times, of the spontaneous discharge of combustible gases from the earth, and there is good reason to suppose that

some of the natural jets of gas were treated as objects of veneration, as they still are by inhabitants of certain parts of India and Persia. The Chinese have for many centuries employed these and similar combustible exhalations for evaporating salt brine and lighting their salt works. These natural exhalations, consisting chiefly of marsh gas and having little luminosity, were traced by Shirley as early as the year 1659 to underlying coal beds. However, owing to the fact that this gas possessed such low illuminating power, no attempt was made to apply either the gas or the coal to illuminating purposes for nearly a century and a half.

All earlier methods of illumination were characterized by the fact that the light was produced as required from the material consumed, as the resinous piece of wood, the fat of the candle or the oil in the lamp in close proximity to the flame-giving light. In other words, the gaseous products which furnished the light were consumed on the spot as fast as they were formed.

During the period when the rivalry between the candle and the new, improved forms of oil lamps was at its height, and just as the oil lamp was gaining complete supremacy, a new method of artificial illumination was discovered that was destined to eclipse all others.

As early as the beginning of the eighteenth century Dr. Clayton, in England, had made experiments in the distillation of coal, producing a gas that was inflammable. About this same period Becker, a German chemist, demonstrated that the coke obtained from the dry distillation of coal could be burned and, later, at the very zenith of the early coke industry, the gas was allowed to escape from the coke ovens since it was considered a useless by-product and, in fact, the gas was often ignited merely for the amusement of the laborers about the ovens.

A little later, 1726, Dr. Stephen Hales published a work in which he described the process of distilling coal in which a definite amount of gas could be obtained from a given quantity of coal.

In 1767 Dr. Watson also published experiments on the quantity of gas yielded by coal, and proved that its combusti-

bility and volume were not altered by passing through water.

Professor Pickel, in 1786, in Wurzberg, lighted his laboratory by means of gas produced by the dry distillation of bones.

Still, in spite of the proof of the value of this gas, no practical application as a source of light and heat seems to have suggested itself to the discoverers until more than half a century later, when William Murdoch, a young Scotch engineer who was employed in the shops of Boulton and Watt, the latter the inventor of the steam engine, and one of the first to appreciate the advantages of gas as an illuminant, manufactured portable gas lamps in which the gas was stored in ox bladders. No great enthusiasm was aroused, however, and the prejudice of the majority of the people did much to hinder rapid development. Watt was one of the very few, at this time, to encourage the young inventor.

About this same time Lebon, a young French engineer, discovered that the gas liberated by heating wood was ignitible and yielded a brilliant flame. With indefatigable energy he pushed the development of his discovery and, in 1802, accomplished the successful illumination of his house with gas. But even in France, where the people were and are always eager to grasp at new inventions and ideas, no great enthusiasm was aroused and probably even more prejudice was aroused against Lebon than was shown Murdock in England. Some looked on Lebon as a crank to be avoided, a few sympathized with him and said that the failure to extend his ideas was not because of the fact that the public did not appreciate, but because of the emptiness of his ideas. The majority, however, did not even take the trouble to give the inventor a thought. Reduced to destitute circumstances, and meeting opposition all around, Lebon finally took his own life.

But history gives to William Murdoch the honor of being the true inventor of gas lighting, since he, in 1792, lighted his own house at Redruth, in Cornwall. This was ten years before Lebon accomplished the same result with gas distilled from wood. Murdoch used a simple form of iron retort and conveyed the gas formed through tinned iron and copper tubes for a distance of seventy feet to the front of his house and there exhibited the wonderful properties of the gas flame

to admiring audiences. It must be remembered that at this time the only source of artificial light were candles and oil lamps and, to the mind educated by centuries of such forms of illumination, it seemed scarcely possible that an illuminating flame could be obtained without a wick, and Murdoch's wickless flame was looked upon in those days with as great wonder as we have bestowed upon Rontgen (X) rays, liquid air, and radium. In the year 1798 Murdoch left Cornwall and return to the engine works of Boulton, Watt and Company at Birmingham, where he lighted up their principal buildings and made many experiments on the best form of retort to use for the distillation of coal and, at the same time, determined the yield of a number of different coals. These experiments continued until about 1802, when many shops in the neighborhood of the factory were lighted by coal gas.

Murdoch, however, was not destined to reap the full reward of his discovery for, in 1799, Lebon took out a patent in Paris for his discoverey of making illuminating gas from wood and gave a public exhibition of it in 1802, which excited the attention of Europe and particularly that of a German named Winsor, who made Lebon an offer for his secret process for Germany. His offer was declined, however, and Winsor returned to Frankfort determined to find out how such a wondrous effect as making common smoke burn with greater beauty than wax or oil had been brought about. Having quickly succeeded in finding how it was to be done, he exhibited before the reigning Duke of Brunswick, in 1803, a series of experiments with lighting gas from wood.

Meeting with indifference in Germany he quickly conceived the idea that wealth and fame was to be obtained in England and, accordingly, he came over to London and, at the commencement of 1804, took over the Lyceum Theater, where he gave lectures on gas lighting. Winsor, while possessed of great perseverance and energy, was rather deficient in chemical knowledge, at one time asserting that our atmosphere was "too strong a medicine," and, at another, "that an admixture of coal gas made it more congenial to the lungs;" and that "gas could never inflame when mixed with air." These and many other misleading statements tended at first to retard his progress, but he was confident, possessed of indomit-

able energy and determined to gain success. He then proceeded to float a stock company and, in 1807, the first public street lighting took place in Pall Mall.

Winsor met determined opposition not only from the oil and tallow interests involved, but from the prejudice and fears of the people. But the greater the opposition the more determined Winsor became. One of his first moves on arriving in England was to change the spelling of his name from Winzer to Winsor. No one understood better than Winsor how to deal with the public and, in the incorporation of the above mentioned stock company, promised untold returns on the capital invested. From the very beginning, according to his idea, every investor of $50 would reap a profit of $1,000 in yearly dividends, while, in a short time, the money would be doubled or trebled. In fact, he advised those of the small investors to give up wage drudgery and retire to the estate of "gentlemen." A few of the more conservative investors would not listen to this proposition, preferring to trust their money to the "sweet simplicity" method of earning 4 per cent on Government bonds. However, the gullible majority were ready with the necessary money. Soon, however, they began to see things in their true light as their prospects for unheard-of financial returns began to grow dimmer and dimmer. Still, Winsor gained great prestige by these actions and was not the man to give up readily. Without admitting total defeat he was able to secure the further financial support of those who still had confidence. But the technical experiments of Murdoch and others about this time gave the gas industry new life and quieted the doubts of the highly conservative, and gas stocks began to bring a high price. While Winsor's efforts to establish a company in London to sell gas as a commodity may or may not be regarded as honorable in consideration of work done and patents taken out by Murdoch and James Watt, Jr., still, much credit must be given the earlier engineers and chemists for establishing the industry on a sounder basis after so much attempted management and operation by "rule of thumb."

In one word, Winsor continually appealed to the cupidity of the stockholders. However, the industry failed to reach

the expected proportions because of crude methods employed in manufacture and lack of chemical knowledge required in purification methods. Still, Winsor was undaunted. It should be borne in mind, however, that Winsor was by no means ignorant of the technical processes involved in the gas industry. In other words, he was schooled sufficiently in technical matters to know all that was necessary. The great possibilities of the new process stood forth as clear in his mind as a cameo and, accordingly, he remained firm in his stand. His hopes for huge financial returns remained almost unlimited. Withal, he was honest with all money intrusted to him, no matter how soon it may have seen its grave. He worked unceasingly and untiringly for the fulfillment of his plans.

Previous to 1816 the general mode of charging customers for gas was at a certain sum per annum for burners of given dimensions, burning from sunset until a stipulated hour, but this method was not satisfactory and it was not until 1817 that a suitable meter was devised by Clegg and Malam.

The manufacture of coal gas in the United States dates from the year 1813, when it was begun by David Melville at Newport, R. I. The first city lighted by gas in the United States was Baltimore, Md., in the year 1816, followed by New York in 1823. Chicago was first lighted by gas in the year 1850.

About 1850 clay retorts began to replace iron ones because of their ability to withstand a much higher temperature and thus produce a much larger yield of gas from a given quantity of coal. After much earlier experimenting it was not until after 1885 that the use of generator furnaces and recuperators became general in the larger coal gas plants.

The exhauster, first introduced in 1841, came into general use about the same time as clay retorts.

The use of iron oxide for the removal of hydrogen sulphide dates back to about 1850 and now is almost the only material employed for the purpose.

Natural Gas.

Natural gas is obtained, directly formed from the earth, being commonly associated with the same geologic strata

peculiar to petroleum—namely, sandstone, sand and limestone. It is probably formed by the natural distillation of organic matter. Natural gas, in commercial quantities, occurs in twenty-three states of the United States, the production in 1911 amounting to 508,353,241 cubic feet, having a value of $74,127,534. At the present time the greatest production of natural gas occurs in the Appalachian region, while that of petroleum is largest in the states of California, Oklahoma, and Illinois, respectively.

The composition of natural gas varies widely with the different wells and localities, but, in general, methane is the active principal, the other constituents being regarded as impurities or dilutents. Therefore, the higher the percentage of methane, the principal heat-producing constituent, the more valuable is the natural gas.

The following analysis of natural gas may be taken as fairly typical:

Constituents—	Percentage by volume.
Carbon dioxide	2.0
Illuminants	0.4
Oxygen	0.4
Carbon monoxide	0.5
Hydrogen	1.6
Methane	93.5
Nitrogen	1.6
Total	100.0

Cubic feet per pound of gas	22.62
Specific gravity of gas (air equal 1)	0.577
Theoretical maximum flame temperature, with air, degrees Fahrenheit	3460
Theoretical maximum flame temperature, with oxygen, degrees Fahrenheit	6490
Cubic feet of air required for combustion of 1 cubic foot of gas	9.027
Heat of combustion of gas with air in gross B. T. U. per cubic foot	958
Heat of combustion of gas with air in net B. T. U. per cubic foot	834

In addition to the wide and increasing use of natural gas for domestic purposes—that is, for lighting, cooking and fuel, the gas is probably utilized most largely in glass works, cement plants, rolling mills and other industrial establishments in the vicinity of the gas fields.

For steam production about 50 cubic feet of natural gas would be required per horsepower hour under average conditions when burned under a boiler, while, if utilized in the best type of large gas engine, only about 9 cubic feet per indicated horsepower hour would be needed. The economy of the internal combustion engine is thus plainly evident.

The demand for gasoline has become so great in the last few years that a profitable industry has arisen based on the separation of the more volatile liquid products, particularly the gasolines, from the "wet" gas escaping from petroleum and natural-gas wells. The process depends on the separation of the various products by compression and temperature regulation conforming with the critical temperatures of the various condensable gases. In other words, the process termed "selective rectification" is employed. It is claimed that from two to six gallons of liquid products per 1,000 cubic feet of gas used may be obtained from this source. The output of the gasoline alone, obtained in 1911 by this method, amounted to 7,425,839 gallons with an estimated value of $531,704. The other liquid products obtained may be stored in steel cylinders under a pressure of about 50 atmospheres and subsequently used in a gaseous form for heating and lighting purposes, especially in isolated districts.

Water Gas.

The fact was known to Fontana, Lavoisier and others as early as 1793 that, when steam is passed through red-hot carbon in any of its many forms, an inflammable gas is produced. It was not, however, until 1824 that any attempt was made to utilize this process commercially. It was then that a Mr. Ibbetson conceived the idea that the volume of illuminating gas could be largely increased by passing steam through the red-hot coke left in the retorts after the carbonization of the coal had been completed. It was soon found, however, that the temperature of the carbonaceous matter was too low and that the large quantities of carbon dioxide utterly ruined the

illuminating power of the coal gas with which it was mixed. Six years after Ibbetson's experiment Donovan attempted to make carburetted water gas by passing steam through coke, heated to a high temperature in a retort, and passing the resulting water gas into a second chamber where it was brought in contact with crude hydrocarbons. Failure attended this attempt, also that of Harris and many others, made during the next twenty years, but, in 1849, another important step toward success was obtained by Gillard, who, at Narbonne, introduced a type of cupola furnace for the manufacture of water gas and adopted the entirely new idea of raising the temperature of the carbonaceous fuel by blasting it with air instead of heating it in a retort fired from without; having raised the fuel to incandescence by its own partial combustion, he then shut off the air and passed steam through the fuel until the temperature was so reduced as to necessitate further blowing with air. It is this process of "blast and run" which has since been employed in all the water gas processes having any claim to success.

After Gillard's time, numerous other attempts were made to introduce water gas processes, but nothing of importance was done until 1875, when Lowe and Tessie du Motay, in the United States, inaugurated practically all the essential principles of the present carburetted water gas systems.

Blue or Uncarburetted Water Gas.

Water gas consists of a mixture of various gases, principally hydrogen and carbon monoxide, formed by the action of steam on incandescent carbon. When uncarburetted the gas is known as "blue" water gas.

The average composition of blue water gas is about as follows:

Constituents—	Percentage by volume.
Carbon dioxide	3.00
Carbon monoxide	43.25
Hydrogen	50.00
Methane	0.50
Nitrogen	3.25
Total	100.00

Cubic feet per pound of gas........................24.51
Specific gravity of gas (air equal 1).................. 0.534
Theoretical maximum flame temperature, with air, degrees Fahrenheit.............................. 3702
Theoretical maximum flame temperature, with oxygen, degrees Fahrenheit.............................. 6034
Cubic feet of air required for combustion of 1 cubic foot of gas.. 2.273
Heat of combustion of gas with air in gross B. T. U. per cubic foot.. 308
Heat of combustion of gas with air in net B. T. U. per cubic foot.. 274

Blue water gas, consisting, as will be noted, principally of hydrogen and carbon monoxide, is practically odorless and gives a non-luminous flame when ignited. It must not be confused with "carburetted" water gas, which is a mixture of blue water gas and oil gas, having a characteristic and pungent gas odor, and which burns with a brilliant yellowish-white flame.

A number of large manufacturing plants maintain small water gas machines for the production of "blue" gas for heating purposes.

Carburetted Water Gas.

Probably over half of the gas used in the United States today for domestic purposes is carburetted water gas. The process of manufacture employed is a modification of the principles as originally stated and developed by Lowe. In this process, steam, in some cases superheated, is passed under comparatively low pressure through a bed of incandescent carbon, previously heated by a blast of air, which, upon contact therewith, is immediately decomposed into its elements, hydrogen and oxygen. The oxygen then reacts with the carbon to form carbon monoxide. If the temperature of the fuel bed is not sufficiently high, or an excess of steam is used, carbon dioxide will be formed.

The blue water gas formed in the "generator" then passes into the "carburettor," consisting of an iron vessel lined with firebrick and filled with a number of alternate rows of fire-

brick extending the entire height of the vessel. Each row of brick is laid at right angles to the row above or below it, while a given spacing is provided between each course. This arrangement of brick, technically termed a "checkerwork" of firebrick, is thus made to serve as a very effective mixing arrangement for the gases passing through it.

A spray of hydrocarbon (gas) oil is admitted above the checkerbrick which, upon striking the hot surface, is vaporized and gasified by the heat and mixes with the blue gas from the generator. It is the oil that furnishes the illuminants necessary for the candlepower and also adds so greatly to the calorific value of the gas.

The mixture of blue and oil gas is finally passed into the superheater, consisting of an additional number of checkerbrick, the effect of which is to render the various hydrocarbon gases more permanent at ordinary temperatures and pressures. This result is probably due to the partial decomposition of some of the higher hydrocarbons into simpler and more stable forms.

After treatment of the gas for removal of impurities, such as tar, hydrogen sulphide, etc., it is ready for distribution and consumption.

Carburetted water gas, giving 24 candlepower as measured by a Bray No. 7 special flat-flame burner consuming 5 cubic feet per hour at 60 degrees F. and under a barometric pressure of 30 inches of mercury would show about the following average composition:

Constituents—	Percentage by volume.
Carbon dioxide	3.0
Illuminants	12.0
Oxygen	0.5
Carbon monoxide	30.0
Hydrogen	31.5
Methane	18.5
Nitrogen	4.5
Total	100.0

Cubic feet per pound of gas	24.51
Specific gravity of gas (air equal 1)	0.699
Theoretical maximum flame temperature, with air, degrees Fahrenheit	3590
Theoretical maximum flame temperature, with oxygen, degrees Fahrenheit	6580
Cubic feet of air required for combustion of 1 cubic foot of gas	5.871
Heat of combustion of gas with air in gross B. T. U. per cubic foot	676
Heat of combustion of gas with air in net B. T. U. per cubic foot	622

Carburetted water gas while used largely for domestic purposes as lighting and cooking, is daily becoming more and more extensively applied to various industrial operations, particularly on account of the ease and cleanliness in handling and the possibility of close temperature regulation.

Coal Gas.

Coal gas is formed by the destructive distillation of coal in retorts or ovens, a number of which, taken together are known as "benches." The retorts may be either of the horizontal, vertical or inclined type, each of which possesses certain advantages. The charge of coal varies from 250 pounds to 10 tons and more, depending on the type and size of retort or oven. The distillation period of the charge, taking place between temperatures of 700 degrees to 2500 degrees F., may be of 4 or even 72 hours duration, governed by the quantity and quality of gas and coke desired. The principal problem in the carbonization of coal is the necessity of obtaining uniform, moderate heat throughout the body of the coal and maintaining this condition during the carbonization period.

The principal impurities in the crude coal gas which must be removed before the gas is fit for commercial use are, tar, ammonia, sulphur, naphthalene ($C_{10}H_8$), and sometimes cyanogen $(CN)_2$. Naphthalene is particularly apt to be present when the carbonization is carried on at very high temperatures

resulting in the partial decomposition of benzene and a subsequent combination of its residues.

A good gas coal would be of the following average proximate composition: volatile matter, 34 per cent; fixed carbon, 60 per cent; ash, 6 per cent; surphur, 1.25 per cent. On carbonization, yielding 16 candle-power gas, a quantity of coke averaging 65 per cent by weight of the coal charged and having the following composition, would be formed. Volatile matter, 1.5 per cent; fixed carbon, 88 per cent; and ash, 10.5 per cent. There should be a gas yield of at least 5 cubic feet per pound of coal, that is, gas of 16 candle-power. Thus 80 candle-feet per pound of coal should be shown while the ammonia (NH_3), should average about 5.5 pounds per ton of coal carbonized.

The average composition of 16 candle-power coal gas would show the following analysis:

Constituents—	Percentage by volume.
Carbon dioxide	2.5
Illuminants	4.5
Oxygen	0.5
Carbon monoxide	7.5
Hydrogen	46.0
Methane	36.0
Nitrogen	3.0
Total	100.0

Cubic feet per pound of gas	28.72
Specific gravity of gas (air equal 1)	0.452
Theoretical maximum flame temperature, with air, degrees Fahrenheit	3570
Theoretical maximum flame temperature, with oxygen, degrees Fahrenheit	6575
Cubic feet of air required for combustion of one cubic foot of gas	5.761
Heat of combustion of gas with air in gross B. T. U. per cubic foot	653
Heat of combustion of gas with air in net B. T. U. per cubic foot	570

In spite of the great value of the by-products obtained from the distillation of coal, it is stated that five-sixths of the coal

which is carbonized in this country has about $40,000,000 of its value dissipated into the atmosphere due mostly to the continued employment of beehive ovens. On the other hand, Germany already cokes over four-fifths of her coke in by-product ovens. It is believed, however, that it is only a question of time before we shall be coking most of our coal in by-product ovens, not only out of economic necessity but from a realization of the immense value of the products now so largely and needlessly wasted.

Pintsch Gas.

Probably the best known application of Pintsch gas is its use for lighting railroad cars, although it is also used for lighting vessels, buoys, etc.

The gas is commonly made by the "cracking up" of heavy paraffin oils or their residues in clay retorts, smaller, however, than those used in coal gas manufacture. The retorts are externally heated, usually by coal. Pintsch gas is now being made, especially in California, where the price of oil is very low, by employing chambers filled with checker-brick, similar to those employed for making carburetted water gas, and using oil as a fuel for heating purposes. The gas, whether made by either process, is next purified, after which it is stored in cylinders or reservoirs under about 10 atmospheres (150 pounds) pressure. When the cylinders are put in use the gas is passed through a suitable regulator which governs the pressure down to that necessary for proper consumption in the burners. The efficiency of the burners is much increased by the use of a special inverted mantle.

Pintsch gas has about the following average composition:

Constituents—	Percentage by volume.
Carbon dioxide	0.50
Illuminants	23.50
Oxygen	0.50
Carbon monoxide	1.00
Hydrogen	18.50
Methane	52.50
Nitrogen	3.50
Total	100.0

Cubic feet per pound of gas........................18.02
Specifice gravity of gas (air equal 1).................. 0.733
Theoretical maximum flame temperature, with air, degrees Fahrenheit 3597
Theoretical maximum flame temperature, with oxygen, degrees Fahrenheit 6785
Cubic feet of air required for combustion of one cubic foot of gas 11.034
Heat of combustion of gas with air in gross B. T. U. per cubic foot 1200
Heat of combustion of gas with air in net B. T. U. per cubic foot 1098

Blau Gas.

Blau gas was named after its inventor, Herman Blau of Augsburg, Germany. Application for patent in the United States covering "method of treating distillation gases to produce an illuminating liquified gas" was filed Dec. 2, 1908, Serial No. 465,710. On June 6, 1911, the patent No. 994,369 on the above named process was granted by the United states.

Blau gas is made by distilling gas oil in iron or clay retorts equipped with hydraulic main and passing the gas so formed, first, through air-cooled condensers, then to the tar scrubber and purifying boxes, containing iron oxide, and from the station meter to a storage holder.

From the holder the gas is drawn into a two or three stage water-cooled compressor, depending on the installation, and compressed first to a pressure of from three to five atmospheres. At this stage the condensation formed from the light oil vapors is drawn off and may be used for any suitable purpose, e. g., for heating the retorts.

Compression continues until such permanent gases as hydrogen and some methane are withdrawn at the end of the final stage, i. e., at about 100 atmospheres, the liquid hydrocarbons remaining, of course, being charged into the cylinders for shipment to the consumer, who, upon opening the valve and thus partially releasing the pressure, may withdraw the gas formed for the purpose desired.

The permanent gases, partially removed at the last stage of

compression, may after withdrawal be used for driving the gas engines operating the compressors.

The gas is transported in steel cylinders ordinarily weighing about 100 pounds apiece. The cylinders are about half filled with the liquid, thus allowing for expansion. Each cylinder of the weight above mentioned contains approximately from 16 to 22 pounds of the liquid when shipped, each pound of liquid giving about 13 feet of free gas, or making a total of 208 to 286 cubic feet of free gas.

Blau gas when liquid has a density of 0.51 compared to water and in the gaseous state has a density of 0.963 compared to air.

The heating value of the gas will average from 1750 to 1800 B. T. U. per cubic foot. The gas consists mainly of about equal volumes of heavy unsaturated hydrocarbons and methane, mixed with slight traces of carbon dioxide, oxygen, and nitrogen. Calculating from the analysis the theoretical flame temperature in air is 3548 degrees F. while in oxygen it is 6756 degrees F. About 17 cubic feet of air is theoretically required per cubic foot of the gas for complete combustion.

The gas, being stored in liquid form in tanks, unlike Pintsch gas which is not compressed to a liquid form, is used for lighting purposes in outlying districts, the burners being equipped with special inverted mantles. The gas may also be used for welding and cutting purposes.

Producer Gas.

Producer gas, now so extensively used in many industrial operations, is the product formed by air being driven or exhausted through a bed of incandescent fuel, generally low-grade coal. Producer gas is used in certain metallurgical operations, in glass and pottery making, in boiler firing, for heating the retorts in coal-gas making, etc. The process furnishes a cheap and ready method for converting solid fuel into a more readily combustible gaseous fuel. When steam is added to the air, as is commonly done, the reactions occuring are essentially as shown by the following equations:

1. $CO_2+C=2CO$
2. $H_2O+C=CO+H_2$

To obtain these results to the best advantage in actual operation it is desirable to have the fuel bed at the highest temperature obtainable, for example, 2800 degrees F., to use a minimum of steam, and, if possible, to provide for the removal of the slag and clinker in a liquid state similar to blast furnace practice.

The newer types of gas producers, especially those of the pressure type in which the air and steam are forced by pressure through the fuel bed, are now being constructed to conform to the above requirements as closely as possible. The smaller types of gas producers are usually those of the suction type in which the air is drawn or sucked through the fuel bed by means of the operation of a gas engine. The suction producer is probably not used so extensively as formerly, it being gradually displaced by the newer and larger pressure systems.

On account of the many variable factors entering into the manufacture of producer gas it is difficult to give a close average analysis. However the following analysis may be taken as typical of ordinary practice.

Constituents—	Percentage by volume.
Carbon dioxide	6.0
Carbon monoxide	22.0
Hydrogen	11.0
Methane	3.0
Nitrogen	58.0
Total	100.0

Cubic feet per pound of gas	14.66
Specific gravity of gas (air equal 1)	0.892
Theoretical maximum flame temperature, with air, degrees Fahrenheit	2775
Theoretical maximum flame temperature, with oxygen, degrees Fahrenheit	3980
Cubic feet of air required for combustion of one cubic foot of gas	1.074
Heat of combustion of gas with air in gross B. T. U. per cubic foot	137
Heat of combustion of gas with air in net B. T. U. per cubic foot	125

Acetylene.

Acetylene gas, C_2H_2, now so familiar to all, was, previous to the year 1892, merely a laboratory curiosity. In that year, however, Thos. L. Wilson, J. M. Morehead and their associates while experimenting at Spray, N. C., on the production of metallic calcium, found that by the use of the electric furnace it was possible to fuse a mass of ground coke with lime to produce calcium carbide in commercial quantities, thereby making acetylene available for general use. Acetylene is immediately evolved upon addition of water to calcium carbide, calcium hydrate being formed as a secondary product.

On account of the high temperature produced when water is added to carbide, acetylene generators are now built with a "carbide to water" feed in which the carbide is fed gradually and automatically into the water as the consumption requires.

Calcium carbide is entirely produced in the electric furnace by fusing a charge of about the following proportions: 2000 pounds of limestone to 1200 pounds of anthracite coal per ton of carbide. The purity of the raw materials is required to be such that the coal contains only a small quantity of ash and the limestone no magnesia nor phosphorus.

The theoretical yield of acetylene per pound of pure calcium carbide is 5.89 cubic feet at a barometric pressure of 30 inches of mercury and a temperature of 60 degrees F. The best grades of the commercial product will yield about 5 cubic feet per pound.

A typical analysis of acetylene is here shown:

Constituents—	Percentage by volume.
Illuminants	96.00
Oxygen	.75
Nitrogen	3.25
Total	100.0

Cubic feet per pound of gas	14.48
Specific gravity of gas (air equal 1)	0.903
Theoretical maximum flame temperature, with air, degrees Fahrenheit	4052
Theoretical maximum flame temperature, with oxygen, degrees Fahrenheit	7885

Cubic feet of air required for combustion of one cubic foot of gas 11.420
Heat of combustion of gas with air in gross B. T. U. per cubic foot 1417
Heat of combustion of gas with air in net B. T. U. per cubic foot 1335

Acetylene gives a brilliant white light when properly burned in a suitable burner. By a comparison of the spectra of all artificial illuminants, it has been shown that the acetylene flame approaches most closely to the same quality of light as that given by the sun.

On account of the ease with which an acetylene plant may be installed the gas is used largely in country districts, villages and small towns where no coal or water gas is available. There are hundreds of towns supplied with acetylene from central station plants.

Actylene when stored in tanks has usually been compressed to a pressure of about 10 atmospheres in the presence of some solvent, acetone frequently being used, and an inert material, such as asbestos, kieselguhr, etc. One volume of acetone dissolves about 25 volumes of acetylene at 60 degrees F.

When acetylene is mixed with oxygen and burned in a suitable blowpipe or torch a very high temperature is produced which commends it highly for welding and cutting purposes. In fact on practically any large structural steel work it is now common to see oxy-acetylene welding and cutting outfits in operation. The oxy-acetylene blowpipe flame while capable of melting any of the materials used in the arts has also been utilized for the preparation of artificial gems where exceedingly high temperatures are of course essential. The temperature of the oxy-acetylene flame is practically the same as that of the electric arc and consequently the highest that it has been possible to obtain for commercial uses.

Oxygen and Hydrogen.

Oxygen and hydrogen may be produced by a number of different methods as is well known to any student of chemistry. However the quality of the product is often not high enough, especially as regards purity, not to mention the ex-

pense of many of the processes, and the result has been that many of these methods have or are now being discarded. Oxygen and hydrogen, especially when desired in large quantities and of a high degree of purity so essential in welding and cutting operations, are now made largely by two processes, the liquid air and the electrolytic.

The liquid air process undoubtedly has the greatest field of operation for it is the cheapest and most adaptable of the two, especially since large quantities of gas may be manufactured with a relatively small machine.

The electrolytic process of manufacturing oxygen is the oldest and best known of the commercial methods since the oxygen is about the purest that can be obtained.

The process of manufacturing electrolytic oxygen is identical with the laboratory method except that it is carried out on a large scale, although there are some changes made in the cells or electrolysers, as the electrodes and hoods are known. The quantity to be manufactured determines of course the number of cells. The cells consist of tanks to hold the water which usually contains caustic soda to increase the resistance and to prevent the current from passing too easily from one pole to another. The electrodes or terminals consist of many blades instead of just simple wires, thus increasing the working surface. Direct current of low voltage is used. The evolved gases after purification are led off from the confining hoods over the cells to the gas holders, from which they are drawn by special compressors and compressed into bottles or drums at a pressure of 2250 pounds per square inch.

Oxy-hydrogen and oxy-acetylene welding have become so well known in the past few years that a detailed description hardly seems necessary. While the flame temperature of the oxy-hydrogen flame is lower than that of acetylene the two processes are equally good for welding purposes. For cutting purposes however, especially where the metal is thicker than four inches, oxy-hydrogen is to be slightly preferred on account of the fact that the flame is reducing while that of oxy-acetylene is carbonizing. Cuts as high as 24 inches thick have been made successfully and economically with the oxy-hydrogen flame.

BEARING CURRENTS IN MACHINERY

BY E. H. FREEMAN, E. E.*

The presence of electric currents in the bearings of machines is not uncommon though the magnitude of these currents is usually small and it is in a few cases only that their presence produces detrimental effects. These currents may be produced by electro-chemical or by electro-magnetic actions; and the damage done by them may be a pitting of the bearings or an impairing of the lubricating quality of the oil. It is understood, of course, that such damages may be caused in other ways, hence these results are not in themselves an indication that serious bearing currents are present.

Currents in bearings that are produced by electro-chemical action result from the use of dissimilar metals in the shaft and in the bearing. These dissimilar metals in the presence of an electrolyte, act like the electrodes of a primary battery and produce a direct current which would carry metal away from one of the electrodes. It is evident that water with some dissolved salt must be present in order to make the battery complete, hence we would look for such action as outlined to occur mainly in machines like pumps where water gets into the bearings. Since the e. m. f. generated by two different metals varies greatly among different substances, it is possible to select materials which will give a very low electromotive force, and therefore, very small current.

Bearing currents that are produced by electro-magnetic induction are found in electric generators and motors, and may be direct or alternating in character. Those that are direct are produced by what may be called unipolar induction. This action may be explained by reference to Fig. 1, which illustrates a diagrammatic longitudinal section through a two-pole revolving field alternator. If the reluctances on the two

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sides of the shaft are not equal some of the flux produced by the current in the field winding will pass around through the shaft and bearings. This flux, shown by dotted lines in the figure, will be moved around the bearing with the rotation of the shaft and generate a voltage therein. Currents produced by this voltage would exist mainly in the bearing metal and its support, there being but little tendency for such currents to pass through a circuit made up of the shaft and bearing metal.

Alternating currents through shaft and bearings must be produced by pulsations or alternations of the flux linked with

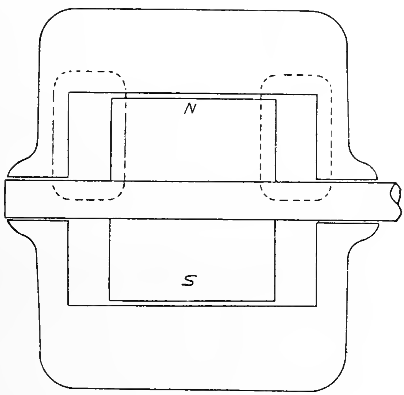

Fig. 1.

a circuit composed of shaft, bearings, and frame of the machine. One very ingenious way has been given for explaining the manner in which they are produced. A reference to Fig. 2, will aid in illustrating this scheme. This figure is a diagrammatic representation of a four-pole revolving field alternator with a frame divided in halves at the plane AA'.

The flux produced by the current in the field winding may be considered as made up of two components, ϕ_1 and ϕ_2, shown by solid and dotted lines respectively in Fig. 2. Now it is evident that the flux ϕ_2 will be less than ϕ_1 for the posi-

tion shown, since ϕ_2 passes through a path of greater reluctances on account of the joints at AA'. Hence there will be a resultant flux linked with the shaft, for this position, in the direction of ϕ_1. After the revolving field has rotated through 90 degrees the reluctances of the joints will be in the path of the flux ϕ_1, hence there will be a resultant flux around the shaft in the direction of the flux ϕ_2. This alternation of the resultant flux around the shaft may be looked upon as giving rise to an alternating voltage tending to produce a current through the shaft, bearings and frame of the machine. This

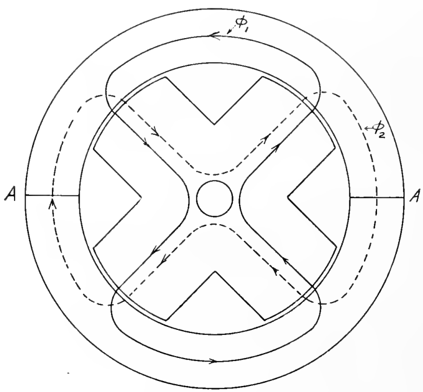

Fig. 2.

voltage has the same frequency as that generated in the armature windings of the machine.

An inspection of Fig. 3 will show that the component fluxes, ϕ_1 and ϕ_2, for a six-pole machine, pass simultaneously through the joints, hence there is no unbalance of these fluxes if the joints have equal reluctances, and there is no resultant flux linked with the shaft. For eight-poles, see Fig. 4, the situation is similar to that for four-poles.

There may be, of course, other combinations than those with a frame split in halves. The frame may be divided into

thirds or quarters; or in the process of manufacture, there may result some inequalities in the reluctances in parts of the magnetic circuit through the armature, such inequalities being regularly or irregularly spaced. In general, if the increased reluctances due to joints or other causes do not act simultaneously and to the same extent upon the component fluxes, ϕ_1 and ϕ_2, a voltage will be developed tending to produce a current through the shaft, bearings and frame of the machine. It is also true that the greater the number of poles

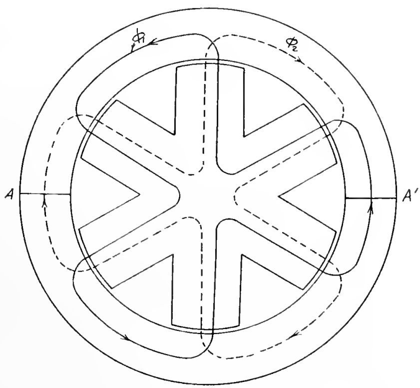

Fig. 3.

the less the effect of joints, for the reason that the fluxes, ϕ_1 and ϕ_2, pass through a greater number of air gaps with a greater number of poles, hence the effect of joints or other inequalities is relatively diminished. We, therefore, find bearing currents of greater magnitudes in high-speed turbine-driven alternators with few poles than in low-speed machines with many poles.

The previous method of explaining the production of bearing currents gives results agreeing with experience, though

the manner of representing the flux is not in harmony with the generally accepted ideas concerning the properties of the magnetic field. The usual manner of showing the magnetic field for a four-pole revolving-field alternator is given in the diagram of Fig. 5. This agrees with the conception that the lines of force of the magnetic field follow the shortest paths and those of least reluctance. But this manner of picturing the magnetic field does not prevent our explaining the production of a voltage in the shaft as the field structure rotates.

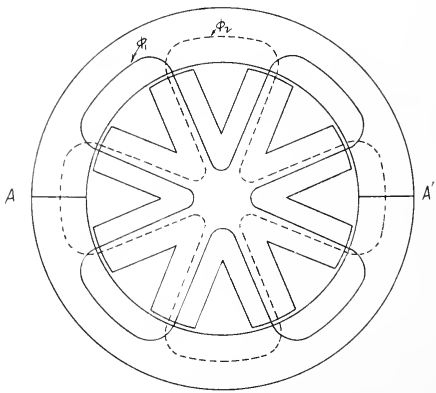

Fig. 4.

It will be seen that the flux from any one pole will shift as the reluctance of a joint passes from one side of the pole to the other. Thus in Fig. 5, pole number 1 has a greater number of lines of force on the right-hand side than on the left-hand side. After the field has turned through 90 degrees, pole number 1 will have a greater number of lines of force on the left-hand side. This shifting of the flux will cut the shaft and generate therein a voltage tending to produce a current around the shaft, bearings and frame of the machine. This

method of explaining the production of bearing currents is not quite as simple as the previous one given, but has the advantage that it agrees with our conception of the distribution of the magnetic field.

Having seen the general manner in which bearing currents may be produced, a number of methods for their prevention or reduction are immediately obvious. The eliminating of the original cause rests with the designer and builder. If there must be joints or other inequalities in the magnetic circuit of

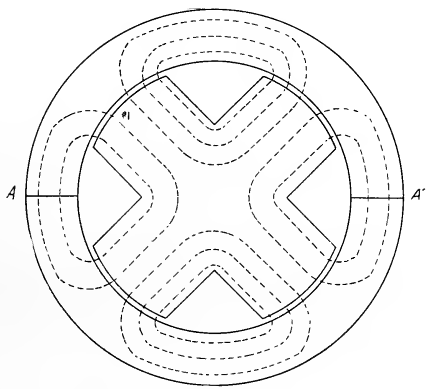

Fig. 5.

the armature, they should be of as low reluctance as possible, or so related in number to the number of poles that their resultant effect is zero.

If the cause is not eliminated, and manufacturers' tests show that this is not always done, it may be advisable to reduce the bearing current by increasing the resistance in its circuit, by shunting it around the bearing, or by introducing a counter-voltage into the circuit. The resistance in the circuit may be increased to a very high value and therefore

reduce the current to practically zero by insulating the bearing support. This is comparatively easy in horizontal-shaft machines, but is more difficult in vertical-shaft generators. It is also necessary in following out this scheme to insulate any oil pipes connecting to the bearings. The shunting of a part of the bearing current around the bearing is accomplished by providing a circuit from the bearing support to a sliding contact on the shaft. This is compartively easy to make, but the resistance of such a circuit must be made very low, in order to carry the greater part of the current. The introduction of a counter-voltage into the bearing current circuit is rather complicated and it seldom is applied.

RAILROAD BRIDGE ABUTMENTS AND PIERS.

BY DUDLEY F. HOLTMAN.*

This article is a general discussion of bridge abutments, piers and their footings. While concrete has no greater durability than first class granite masonry it is admirably adapted to the construction of bridge substructures. The following discourse will deal only with concrete structures.

In general, the footings of all structures should be so located and shaped as to obtain as little eccentricity of loading as practicable in order to obtain the greatest possible uniformity of bearing throughout the extent of the footing. There are, of course, many cases where this would prove uneconomical. Where eccentricity is unavoidable, the determination of the resultant bearing pressure is based on the straight line variation of the bearing.

Avoidance of eccentricities and the resultant variation in bearing is much more important in soft foundations than on hard foundations, such as rock. In the case of foundations on rock, the eccentricity should not exceed an amount which would give a factor against overturning about the toe of the footing of less than one and a half or two, providing also that the allowable bearing must be within safe limits. When the foundation is earth the resultant pressure must not in any case fall outside the middle third and in many cases it must be well within this limit.

The man in the office must usually follow the recommendations of field engineers in regard to allowable bearing on soil or piles. If the structure is important, or if for any other reason the security of the foundations is especially important these recommendations should be obtained before completion

*Class of 1912. Bridge Department, Rock Island R. R., Chicago, Illinois.

of the plans. Various tables serve as a guide in designing foundations on soil, for under ordinary conditions we know about the bearing different soils, such as sand, clay, gumbo, etc., will withstand. When a structure is on pile foundations, the allowable bearing per pile depends a great deal on the nature of the structure to be carried. Where a reasonable amount of settlement will not result seriously, a much higher bearing per pile may be allowed than in the case of a structure such as an arch, where very slight settlement would seriously endanger the integrity of the bridge.

The inadequacy of driving test piles over a limited area is brought forcibly to mind. In the design of a 3-50 foot span arch bridge, recommended bearing values were used and plans for the structure completed and sent out; in fact, all piles in the two piers and abutments had been driven. The pile record was something in the nature of a revelation, however. Piles under one abutment and the piers would develop fifty per cent more in bearing than they were calculated for, but the other abutment piles were a curiosity. They would support only three-quarters of a load they had been calculated for. If the structure had not been an arch bridge the footing plans for this abutment might have been revised and the bridge built. A settlement of this abutment, however slight, might, in this case, have destroyed the entire continuity of the arch and caused unsightly cracks if not actual failure. Accordingly, the arch design was discarded and 3-60 foot ballast deck girder spans substituted. The bridge was on a curve and considerable difficulty was encountered trying to fit new pier and abutment footings over the piles already driven. If numerous test piles had been driven the condition of the foundation at this abutment might have been discovered in time to save several months work.

Before taking up some of the phases of economical design it might be well to discuss briefly the circumstances that should determine the type of structure. There are so many factors entering in to this problem that have a decided effect upon the ultimate economy of the structure that only a few of the more important ones will be considered here.

A bridge abutment has two duties to perform. It must retain the fill and support the track to the point where the

track passes onto the bridge as well as furnish the end support for the super-structure. The walls of an abutment, then, must support the head of the embankment and must be proportioned to resist the horizontal earth pressure or else some means must be provided for the sloping of the embankment in such a way that this horizontal pressure will be practically eliminated as shown in Fig. 1. This view shows the west abutment of the new bridge over the Des Moines river of the Chicago, Milwaukee & St. Paul Railroad. The location of the abutment and the angle of the wings as well as the length of the wings or tail walls (in the case of "U" abutments) should be determined so as to retain the fill in

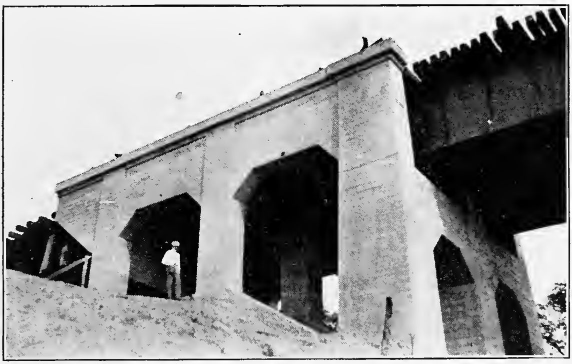

Fig. 1. West Abutment, Des Moines River Bridge.

such a manner that the toe of the embankment will not advance any farther than the conditions of the site will permit. The complete cone of the embankment head should be considered to make sure that the slope does not project an undue amount or spill into the river or roadway at some point at a distance from the abutment on either side. This is likely to occur in a skew crossing. In cases where the stream for a river crossing makes a bend just above the bridge or where the current is particularly rapid the necessity for riprap should be noted.

For single track, mass wing abutments are most economical where the distance from base of rail to the top of footing is

less than fifteen feet. For double track the upper limit is somewhat higher. Where the above distance exceeds fifteen feet, reinforced concrete "U" abutments and trestle abutments are the most favorable types. Conditions at the site have a very decided effect upon the relative economy of the various types and it is frequently necessary to make detailed estimates before a selection can be made.

Mass wing abutments shall always be proportioned so that the body and wings are stable independent of each other, for all conditions of load. To design economically a retaining wall of any kind and insure stability, is a problem that is

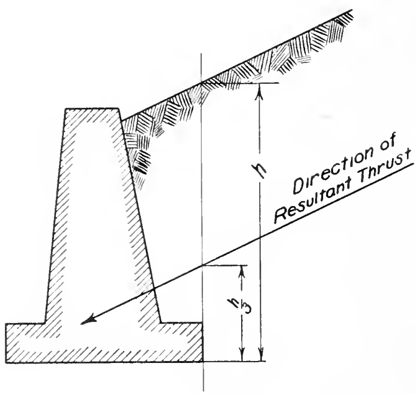

Fig. 2.

not susceptible of accurate mathematical solution. A great many formulas have been advanced that deal with earth pressure under different conditions, and, as a rule they all give results that are safe; but the formulas themselves are necessarily based on assumptions that are more or less unknown. There is little or nothing to be gained by applying these formulas to determine the direction and magnitude of the resultant earth pressure on a wall whose back surface is inclined.

It is sufficiently accurate for ordinary cases to consider the horizontal earth thrust acting against an imaginary vertical

plane passing through the back face of the footing. The magnitude of the resultant thrust will be $\frac{0.3\,wh^2}{2}$ where w is the weight of a cubic foot of earth and h is the distance in feet from the point where the imaginary plane intersects the earth surface to the bottom of the foot. This thrust will be applied at a distance from the bottom of the footing equal to $\frac{h}{3}$ and it will act in a direction parallel to the plane of the earth's surface (see Fig. 2). The body of a mass wing abutment must be designed to resist horizontal pressure due to live load in addition to the earth pressure. To design the body of the abutment, consider the forces acting on a lamina one foot thick, bounded by two vertical planes perpendicular to the front face of the abutment. For this purpose assume the vertical live load as distributed over a width equal to the transverse spread at the top of the footing, provided, however, that this distribution should not be taken wider than would prove reasonable, considering the shape of the base of the neat work. Lateral live load pressure should be assumed as effective at the extreme top of the wall.

Batters on the faces of abutment and wings should not exceed four inches in one foot on account of the difficulty of anchoring forms. When the wings make an angle with the body greater than forty-five degrees they should be separated from the body at the angle by a keyed joint.

It is essential in the design of a "U" abutment that the loads and pressures be considered in all possible combinations. Cases have occurred in abutments of this type in which the heel of the long tail wall footings has settled during construction causing the side walls to be as much as two or three tenths of a foot lower than intended and producing cracks in the structure. This condition must be guarded against particularly where the overhang of the tail walls is great. Fig. 3 shows a "U" abutment built by the Chicago, Milwaukee & St. Paul Railroad at Cambridge, Iowa, in which the load due to the overhanging side walls was brought down to the footing by means of a column. The foundation pressures for

these abutments must be carefully analyzed for the condition of no fill, for the total dead load on the completed structure and for the loadings it will receive under traffic. Except in the case of direct live loads applied to portions of the neat work, impact should not be considered in the design. "U" abutments when built for double track are usually constructed with a center wall parallel to the side walls to give stability to the structure and furnish support for the tie walls. Walls of this kind are hard to build, especially when the tie walls are deep and spaced close. The form work becomes compli-

Fig. 3. "U" Abutment at Cambridge, Iowa.

cated and it is not easy for the workmen to move around in a box-shaped affair of this kind. The difficulties can be avoided partly by cutting down the height and length of the center wall as much as possible, or where there is sufficient footing area back of the front wall a buttress may be placed on the center line between tracks to stiffen the front wall and bridge seat. When this is done the tie walls will either have to be supported at the middle by posts or made deep enough to resist shear and bending for the entire

distance between outside walls which is about twenty-five feet for tracks thirteen foot centers.

Let us now turn from the end supports of the bridge and note briefly the forces that must be considered in designing the less complicated but more massive intermediate supports.

Ordinary bridge piers are mass concrete structures and their design is usually a simple matter. They must be designed to be stable under vertical live and dead load and the secondary loads of traction, wind, centrifugal force, ice pressure and drift. Low piers for double track structures are generally safe against the pressure due to lateral forces but in high single track piers the effect of the wind, ice and drift should be carefully investigated.

In general, piers for ordinary structures out in the country need not be drawn up with much regard for architectural detail. Where the situation demands especially good appearance, round ends and a coping might be used. When the pier is located in a stream of appreciable current a pointed nose is generally provided, and where necessary to avoid excessive eddy on the downstream end, the rounded end should be used there.

To avoid extending the footing an excessive distance on the upstream end, in cases where the top of the pier is more than about eight feet above high water line, the nosing might be cut off about one foot above high-water and the upstream end of the pier above that point given the same batter and made the same shape as the down stream end. When much ice or drift is likely to be encountered the upstream end of the pier should be shod with a rail enclosed into the concrete by bent bars.

In pier footings, as in footings of any kind, the depth should be sufficient to take care of the shearing stresses due to the offset of the edge of the footing from the neat work line. Bent bars are never used in mass footings and when steel is required to take moment large bars spaced one foot or more are generally preferable to smaller bars placed closer. Stepped footings are often used for piers, but the economy of this is doubtful, except in the case of large footings, on account of the extra form work and labor required.

While the points discussed have been somewhat general, they deal with some of the elements that govern a good design.

CLEARANCE AND ITS RELATION TO VOLUMETRIC EFFICIENCY OF AMMONIA COMPRESSORS.

BY C. E. BECK.*

Singular as it may seem, clearance in ammonia compressors has received but little attention in the theoretical relations which govern the high efficiency compressor. It is common among manufacturers to look upon clearance with the view of eliminating it, and thus afford a means of producing a smaller compressor of large capacity which will market much more easily. With possibly one exception the theory of clearance has not been treated scientifically by refrigerating engineers, yet some very excellent textbooks have covered the subject in the compression of air.

In analyzing this matter we find that it can be treated quite fully when classified under three heads viz., (1) horse power of indicator diagrams, with and without clearance in theory and practice, (2) horse power per ton of refrigeration, (3) conditions which render the indicator cards misleading.

The two fundamental laws which manifest the behavior of all perfect gases are the well known laws of Charles and Boyles. The former states that with the pressure constant the volume of a given weight of a perfect gas varies in direct proportion with its absolute temperature. Boyle's law states that with the temperature kept constant the volume of a given weight of a perfect gas is inversely proportional to the absolute pressure. The characteristic equation representing these two laws is expressed by

$$p\ v = R\ T$$

In this expression R is a constant which is equal to the foot pounds of external work produced by the increase in

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*Class of 1911. Sales Manager, Chicago Office, De La Vergne Machine Co., of New York.

volume at constant pressure when a unit mass of a gas is changed 1 degree in temperature. Pressure and volume are represented by p and v respectively.

It is a known fact that gases have two specific heats, one the specific heat at constant volume S_v which is the heat required to raise the temperature of a unit mass of a gas one degree when the volume is kept constant and the other the specific heat at constant pressure S_p which is the amount of heat required to raise the temperature of a unit mass of a gas one degree when the pressure is kept constant. In determining the specific heat at constant pressure we can assume that a unit mass of gas is contained in a vessel having a movable piston and, in heating, any attempt by the gas to increase its pressure will be compensated for by the movement of the piston, thus changing the volume and maintaining a constant pressure. In doing this, heat is not only required to the extent of S_v but also in doing external work on moving the piston against atmospheric pressure. Thus we have

$$S_p = S_v + \text{external work} = S_v + \frac{R}{778}$$

S_v and S_p are constant for perfect gases and therefore their ratio, which is a widely used quantity, is also a constant.

$$\frac{S_p}{S_v} = \frac{.508}{.391} = n = 1.3$$

and the above equation now becomes

$$S_p = n\,S_v$$

therefore

$$S_v = \frac{R}{778\,(n-1)}$$

When there is a change in a gas such as its compression in a non-conducting vessel, heat is not communicated to nor subtracted from it and this is termed an adiabatic compression and is represented by the following equation, which may be deducted from the above:

$$pv^n = p_1 v_1{}^n = \text{constant}$$

There will be some deviation from the value of $n = 1.3$ if there is a leakage of heat through the cylinder walls but the process of compression as met in practice is completed in so little time that n is not so much affected in this way as by the leakage through piston and valves.

Referring to Fig. 1, let A B C D represent an indicator diagram.

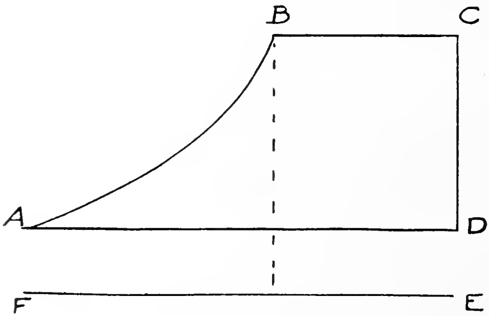


Fig. 1. Compression without clearance.

Let the work done = work of compression + work of expulsion — work of admission

$$W = W_C + W_E - W_A$$

and in any book on thermodynamics will be found the following equation expressing this work:

$$W = \frac{n}{n-1} p_1 v_1 \left[\left(\frac{p_2}{p_1} \right)^{\frac{n-1}{n}} - 1 \right]$$

from which the main effective pressure is obtained by dividing by v.

$$M.\ E.\ P. = \frac{n}{n-1} p_1 \left[\left(\frac{p_2}{p_1} \right)^{\frac{n-1}{n}} - 1 \right]$$

Referring to Fig. 2, let $A\ B\ C\ D\ E$ represent a diagram with clearance, when $A\ D =$ compressor stroke and $C\ H =$ clearance volume, including all ports and valve pockets. The gas is discharged at a pressure p represented by the line $B\ C$ and at C the piston reverses its stroke resulting in the closing of the discharge valve. The volume of gas trapped in the space $C\ H$ now begins to expand along the line $C\ E$ and at E the suction valve opens. It is clear that the volume of gas taken in on the suction stroke is $E\ A$ and from the ratio of $A\ E$ to $A\ D$ we get the "apparent volumetric efficiency."

The apparent volumetric efficiency would also be the true volumetric efficiency if the temperature of the gas after it had entered the cylinder were the same as that in the suction

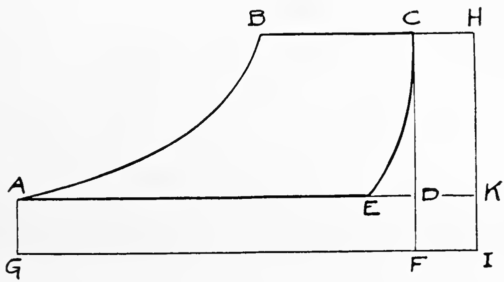


Fig. 2. Compression with clearance.

pipe. If we let T_1 be the suction temperature and T_0 the temperature of the gas within the cylinder at the end of the suction stroke, then the true volumetric efficiency would be the apparent volumetric efficiency multiplied by the ratio $\frac{T_1}{T_0}$ It is very evident that the indicator does not show this and with the temperatures continually changing in a compressor it is impossible other than by calculation to determine the temperature at the completion of the suction stroke.

There are also conditions in the design of a compressor which greatly effect the volumetric efficiency; such as the inlet valves being too small and causing the temperature at the end of the suction stroke to be less than that in the suc-

tion pipe. On the contrary, the suction passages and piping may be extra large and the large volume of gas set in motion during the suction stroke will by its inertia, produce a higher pressure in the cylinder than in the suction line.

In taking up the analysis of the clearance diagram we may consider it as two non-clearance diagrams, *A B H K* and *C H K E* where we may term *A B* and *C E* both adiabaties.

When considering the equation for the work done in compressing and discharging a gas, we have

$$W = p_1 \, v_{AK} \frac{n}{n-1} \left[\left(\frac{p_2}{p_1} \right)^{\frac{n-1}{n}} - 1 \right] - p_1 \, v_{EK} \frac{n}{n-1} \left[\left(\frac{p_2}{p_1} \right)^{\frac{n-1}{n}} - 1 \right],$$

$$\text{Whence } W = p_1 \, (v_{AK} - v_{EK}) \frac{n-1}{n} \left[\left(\frac{p_2}{p_1} \right)^{\frac{n-1}{n}} - 1 \right];$$

from which it is noted that $v_{AK} - v_{EK} = v_{AE}$ the actual volume of gas compressed. Therefore with the above general equation, the work done in compressing and expelling the gas may be determined if for the volume of gas handled we substitute the actual volume compressed.

A point to be observed at this time is that in determining the *M. E. P.* from an actual indicator card with a planimeter, the length *A E* should be taken if the horse power is calculated from the quantity of gas compressed. If the *M. E. P.* is based upon the total displacement, then the length *A D* is taken.

This point being an important one, there is still a more simple way of looking at it when we consider its application to the indicator diagram.

Area of *A B C D G* = *M. E. P.* × length of stroke, *L*.

Area of *A B E G* = *M. E. P.* × 1.

Area of *B C D E* = *M. E. P.* × *L* — 1.

But area *B C D F* = $M.\ E.\ P._{no\ cl.} \times L_2$.

Since these two volumes are equal,

$$M.\ E.\ P. \times L - 1 = M.\ E.\ P._{no\ cl.} \times L_2.$$

whence

$$M.\ E.\ P._{no\ cl.} = M.\ E.\ P. \times \frac{L - 1}{L_2} = M.\ E.\ P. \times \frac{ED}{FD}$$

Therefore by multiplying the *M. E. P.* for no clearance by the

ratio representing the volumetric efficiency we obtain the *M. E. P.* for the clearance diagram.

The writer has had access to the results of a great many tests conducted along these lines and is able to present some diagrams taken from horizontal double acting compressor designed to receive plates on the piston which were used to reduce or increase the clearance. Before any tests were conducted the actual clearance of the compressor, as well as the total displacement were determined by filling the spaces with oil. The average clearance for the head and crank end was 1.47 per cent, this being afterward increased to 3.87 per cent.

The average apparent volumetric efficiency for the head and crank end was 94.05 per cent. For the large clearance the

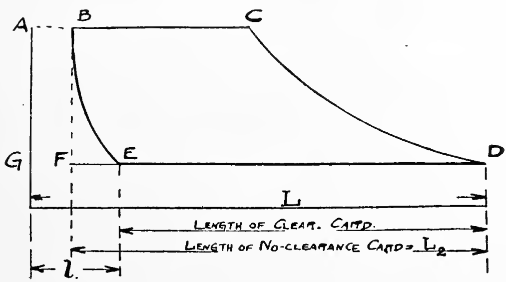


Fig. 3.

average volumetric efficiency was 85.04 per cent and the quotient obtained by dividing the large by this is 1.106.

The mean effective pressure for the no clearance steam engine diagram = 33.93 pounds and for the clearance diagram = 30.57 pounds, hence

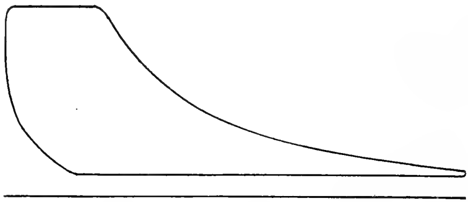
$$30.57 \times 1.106 = 33.81 \text{ pounds.}$$

This clearly shows that as the clearance increased and there was more re-expansion in the compressor, the *M. E. P.* in the steam engine increased in the same proportion or in other words the *M. E. P.* in the steam engine increased in direct proportion with the volumetric efficiency.

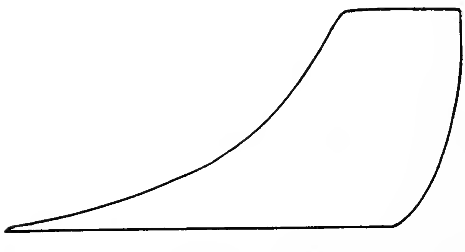
Something has already been said about how the apparent volumetric efficiency becomes the actual volumetric efficiency

INDICATOR SET No. 1.

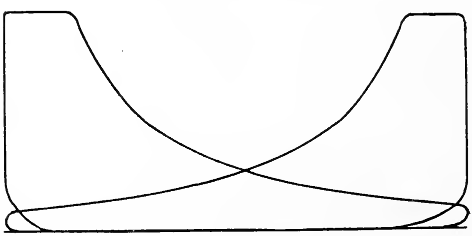
Indicator Cards, 11½x20 In. Compressor Cylinder, 17x20 In. Steam Cylinder, with 3.87% Clearance.



APP. VOL. EFF. = 84.45%.
M. E. P. = 60.95 bs.
Condenser press. = 170 lbs.
Suction press. = 16 lbs.



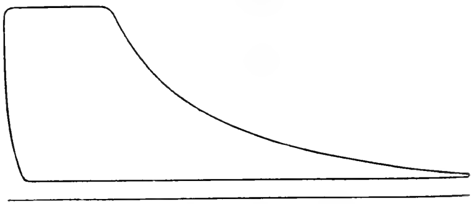
APP. VOL. EFF. = 85.63%.
M. E. P. = 66 lbs.
Condenser press. = 170 lbs.
Suction press. = 16 lbs.



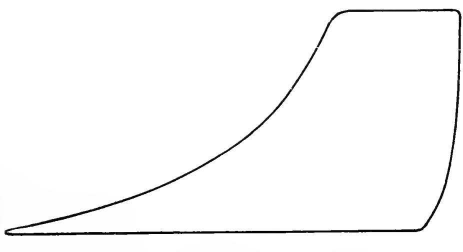
M. E. P. = 30.57 lbs.

INDICATOR SET No. 2.

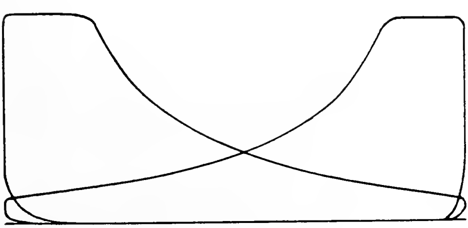
Indicator Cards, 11½x20 In. Compressors, with 1.47% Clearance.



APP. VOL. EFF. = 95.2%.
M. E. P. = 70 lbs.
Condenser press. = 170 lbs.
Suction press. = 16 lbs.



APP. VOL. EFF. = 92.9%.
M. E. P. = 69.19 lbs.
Condenser press. = 170 lbs.
Suction press. = 16 lbs.



M. E. P. = 33.93 lbs.

when the temperature in the suction line is the same as at the end of the suction stroke. Practically speaking this cannot be, because values and cylinder parts are bound to heat upon discharging hot gas and an incoming cold gas encountering these hot surfaces is sure to take on some superheat. Ammonia gas is a poor conductor of heat and to avoid its becoming heated only slightly, it is advisable in designing a compressor to make the parts and passages of ample size,

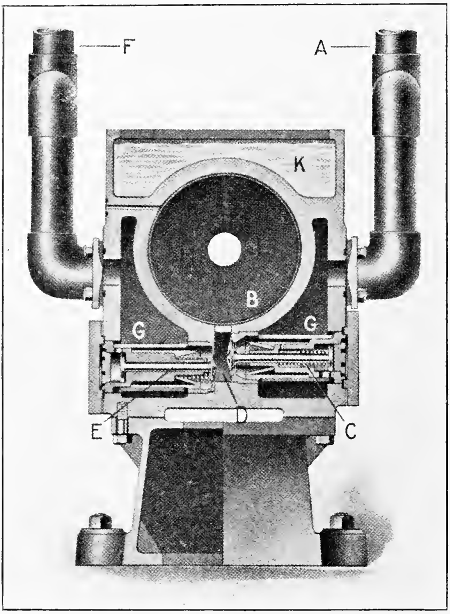


Fig. 4. Horizontal Safety Compressor (De La Vergne Make).

give the valves plenty of lift, and aim to keep a minimum of surface per unit of cubical contents in order to reduce the heating affect to a minimum. By properly water jacketing the compressor heads so as to include the discharge valves, a more even temperature can be maintained in the suction gas.

TABLE I.

18¼x33 Horizontal Twin Compressors with 24x48x33 Horizontal Cross Compound Steam Engines.

TIME	2 Mach. R. P. M.	3 Mach. R. P. M.	Condr. Press.	Suct. Press. Mercury.	NH_3 Liq. Temp.	No. 2 Cooler In.	No. 2 Cooler Out.
10:45 a. m.	42	44	150	15¾	80	6	18
11:15 a. m.	41	42	160	16¾	83	6	17½
11:45 a. m.	41	45	180	17¼	85	7	18¼
1:00 p. m.	42	45	160	15	79½	4½	16½
1:30 p. m.	42	46	160	15½	79	6	17½
2:00 p. m.	41	44	175	16⅞	79	7	19
2:30 p. m.	41	44	168	16¾	81½	7	19
3:00 p. m.	43	45½	168	16½	82	6½	18¾
3:30 p. m.	43	46	169	16½	82¼	6½	18½
4:00 p. m.	42½	44½	165	16⅛	82	6¼	18¼
4:30 p. m.	41	41	165	16¼	82	6¼	17½
5:00 p. m.	42½	46	165	15½	82	6	17½
	42	45	165 5	16.23 lb.	81.4° F	6.25° F	18 1 Less 5* =17 6

TIME	No. 3 COOLER. In.	No. 3 COOLER. Out.	Gas Temp. at Top 2 Coolers.	3 Coolers.	Gall. Brine Min.	Dis Temp. 2 Comp.	Dis Temp. 3 Comp.
10:45 a. m.	5½	18	4	3	943	237	237
11:15 a. m.	5¾	17½	4	3	936	240	238
11:45 a. m.	7	18¼	4	4	952	245	243
1:00 p. m.	4½	16½	3	3	952	250	245
1:30 p. m.	5¼	17½	4	3	952	245	245
2:00 p. m.	7	19	6	4	952	246	254
2:30 p. m.	7	19	6	4	952	247	250
3:00 p. m.	6½	18¾	6	4	952	248	255
3:30 p. m.	6½	18½	6	4	952	245	248
4:00 p. m.	6¼	18¼	6	4	952	243	245
4:30 p. m.	6¼	17½	6	4	952	241	243
5:00 p. m.	6	17½	6	4	952	245	247
	6 16° F	18.1 Less 5* =17.6			950 Gal. per Min.	Disch. Temp. 245 8	

*Deduction for thermometer correction.

Average total tonnage, 373.23. App. efficiency, 95.38%. Average total H. P. 517.88. Vol. efficiency, 82.15% steam I. H. P. per ton 1,398.

TABLE II.

11½x20-In. Compressor.

TIME.	Reading of Rev. Counters R. P. M. Mach.	Cond. Press.	Suct. Press.	Dis. Temp.	Liq. Temp.	Gal. Brine Minute.	In.	Out.
11:00	614598	165	15	259 5	82	91	20.	10.
12:15	615416	165	16	259.5	83.	91	18.5	11.5
12:30	616220	162	14¾	259.5	83.	91	16.5	9.5
12:45	616986	165	16¼	254	83.5	91	18.5	11.0
1:00	617775	165	15½	255	83.5	91	19.5	10.5
1:30	619383	166	15¼	260.	82 5	91	20.5	10.5
2:00	620999	170	16¼	265.	84.	91	22.5	12.
2:30	622588	172	16¾	258	82	91	22.5	11.
3:00	624190	160	14½	264.	84 5	91	21.5	13.5
3:30	625023	160	18	229.	81.5	91	19.5	10.
4:00	627392	178	15½	244.	89.	91	17.5	10.5
Average	53.30	167	15 8	255	83.5°	91	19.73°	10.9

Total tonnage, 28.123. Apparent vol. efficiency, 94.05%. Total H. P. 39.381. Actual vol. efficiency 83.21% steam I. H. P. per ton, 1,401.

Having proved by the above results that clearance is not a detriment so far as the horse power required to compress a given mass of gas is concerned, it leaves the way open for the design of compressors having large valves and passages. It is far better to design a compressor with ample proportions throughout permitting the clearance to be anything within reason, than to sacrifice valve areas and lifts and even safety. The amply proportioned safety compressor with large clearance may appear to be handling less gas than one of small clearance when viewing it from the indicator card, but let temperature have its rightful consideration and the large clearance safety compressor will almost invariably show the highest true volumetric efficiency.

In the tests presented in this paper the temperature of the discharge gas ranged from 250 to 260 degrees F. while the temperatures of the back head, where a thermometer was placed, averaged 136 degrees F., showing a marked cooling effect. The temperature of the gas was only two degrees superheated on entering the compressor and if you will notice the illustration on page 122, it is clearly seen that upon opening, the suction valves acts as a shield for the hot discharge valve and deflects the gas in a thick strata upward into the cylinder. Knowing as we do that gas is a poor conductor of heat there is little chance in this style of compressor of the gas taking on any appreciable amount of superheat.

It is most unfortunate that there is no possible way to determine the extent of suction superheat and only by figures can it be obtained. It is, however, a very important point to consider with a view to economy and affords great food for further study. In a recent test made under the most exacting conditions with 16 pounds gauge suction pressure and 166 pounds gauge condenser pressure, an actual volumetric efficiency of 82.15 per cent, was obtained and a ton of refrigeration was produced on 1.39 indicated horse power of the steam engine.

In this test the apparent volumetric efficiency taken from the indicator card was 95.18 per cent. and from this we calculate that the suction heating effect was about 83 degrees F. with but 2 degrees F. superheat in the gas entering the compressor.

The tonnage is a direct factor of the displacement of a compressor and from this it follows that with constant suction superheat the tonnage is also directly proportional to the horse power consumed. Suppose then, that the superheat be decreased by the expansion of the gas trapped in the clearance space, it is evident that this expansion has a cooling effect upon surfaces exposed to the in-rushing gas thus tending to keep down the superheat.

In a plant where the writer has chanced to make some observations there were two double acting compressors, one a non-clearance and the other a clearance machine. They both took gas from the same suction line and the suction superheat was 9 degrees F. Thermometers were placed in the discharge headers and it was interesting to note that the discharge temperature on the non-clearance machine was 12 to 15 degrees F. higher than on the clearance compressor. The suction pressure, temperature and head pressure all being the same indictated quite clearly that the high discharge temperature of the non-clearance machine must have been due to suction heating.

So far in this paper ammonia has been treated as a perfect gas and such is the case when it enters a compressor in a slightly superheated condition. With this in mind the expansion due to clearance should not be confused with re-expansion due to liquid where compression tends toward the isothermal resulting in a lowering of the valve of n.

It is thought by some people that a wet suction gas increases the volumetric efficiency of a compressor and requires less horse power to compress a unit volume than dry gas. This has not been the case in the writer's observations for the re-expansion due to the presence of liquid has been found to be much more than that due to large clearance.

From a theoretical standpoint the presence of liquid in reducing the value of n should reduce the horse power required, but tests prove differently and presumably because of the poor conductive qualities of the gas. The liquid lays in the bottom of the compressor in a globular state, does not cool by evaporation but merely fills the cylinder with a gas has done no useful work.

As was stated in the fore part of this paper, little attention has been devoted to the theoretical analysis of the conditions governing refrigeration and not only is there room for further study on the above subject but also upon many other phases of its development. Refrigeration in some form or other is used in almost every industry of today and its future presents an uncrowded field for every young engineer.

FILTERS.

BY CHARLES NESS.*

Filtration is the act of separating suspended matter in a liquid by means of passing through some porous material such as cloth, paper, sand, charcoal, etc.

Until a comparatively short time ago filtration was unknown to anyone except those engaged in such industries as the manufacture of chemicals and liquors. Today, however, filtration of our water supply is looked upon as a necessity and provision is made for water filtration in every large building. Filters have been installed for private use, and in many instances municipalities have erected plants for the filtration of the entire water supply. Cincinnati is a notable example of a city accomplishing this.

The filtering medium contains a number of fine passages which allow the liquid to pass through but which retains the coarse suspended matter. In addition to this straining action there is an adhesive action which causes particles which impinge upon the various surfaces to be retained.

Ofttimes this suspended matter is in such a fine state of division that to have a filtering medium fine enough to retain this matter would be to reduce the rate of filtration greatly. In such a case a "coagulant" is used. This is some substance which forms a sticky mass over the filtering surface and acts as a filter itself. The filtering medium retains this sticky mass while in turn this sticky mass retains any suspended matter that comes in contact with it.

The most common coagulant for water filtration is aluminum sulphate, known to the filter trade as alum. This reacts with the lime in the water and forms the well-known,

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*Class of 1912, Gas Inspection Laboratory, City Hall, Chicago, Illinois.

gelatinous precipitate of aluminum hydroxide according to the following equation:

$$Al_2\ (SO_4)_3,\ 18\ H_2O+3Ca\ (HCO_3)_2=3\ Ca\ SO_4+2\ Al\ (OH)_3+6\ CO_2+21\ H_2O \qquad (1)$$

Should the water not contain enough lime to react with the alum, slaked lime is added according to equation (2)

$$Al_2\ (SO_4)_3,\ 18\ H_2O+3Ca\ (OH_3)_2=3\ Ca\ SO_4+2\ Al\ (OH)_3+18H_2O \qquad (2)$$

Ferrous sulphate is also used as a coagulant, the action being similar to that of alum except that the hydroxide of iron is formed instead of aluminum. Alum is preferable to iron sulphate, however, owing to the fact that when ferrous sulphate in solution comes in contact with lime present in the water as the bicarbonate, as it usually is, it reacts according to equations 3, 4 and 5:

$$Fe\ SO_4+Ca\ (HCO_3)_2=Ca\ SO_4+Fe\ (OH)_2+2\ CO_2 \qquad (3)$$

$$CO_2+H_2O=H_2\ CO_3 \qquad (4)$$

$$2H_2\ CO_3+Fe\ (OH)_2=Fe\ (HCO_3)_2+2\ H_2O \qquad (5)$$

As is seen the sulphate of iron is changed by the lime into ferrous hydrate and the ferrous hydrate in the presence of carbonic acid, which is in solution, is changed to ferrous bibarbonate. Should there be any acid such as carbonic acid present in the water, lime is added to neutralize or precipitate it, thus preventing any dissolving action on the ferrous hydrate.

$$H_2CO_3+Ca\ (OH)_2=Ca\ CO_3+2\ H_2O \qquad (6)$$

For liquids other than water, numerous chemicals such as talc, isinglass, albumen, etc., are added to serve a purpose similar to that of the coagulant.

Filters can be divided into six classes. These are:

Sand filters.
Charcoal filters.
Stone filters.
Pulp filters.
Filter presses.
Paper filters.

This classification is made only for the simplification of the

discussion of filters and no attempt has been made to classify them according to their merits and importance.

Sand filters are probably the most common and are used almost entirely where there is a great deal of liquid to be filtered. This is so in the case of the filtration of the water supply or the sewage of an entire city.

Sand filters are tanks of wood or metal usually from five to seven feet in height. They may or may not be open at the top according to their use and whether they are pressure or gravity filters. At the bottom is the strainer or collector system, consisting of a network of strainers tapped into col-

Fig. 1

lector pipes leading into one large central receiving or effluent pipe.

Above this is the sand which varies from a coarse gravel at the bottom up to a fine sand at the top. The height of this bed is 9 inches of gravel and from 27 to 33 inches of sand. Above the bed is an inlet pipe with some provision, usually a funnel, to distribute the water and to collect the waste water when washing the filter.

The pipe layout on the outside may be like that of figure 1 or may be some similar arrangement such as a three way

valve by which the same end is derived. This general pipe arrangement is to provide the following:

1. An inlet for applied water at the top.
2. An outlet for filtered water at the bottom.
3. An inlet for wash water at the bottom.
4. An outlet for waste water at the top.
5. An outlet for waste water at the bottom.

A single unit filter of this type would be operated as follows: When filtering, the upper and lower right hand valves should be open and the others closed. When washing the lower right hand, the upper right hand and the lower left hand valves should be closed and the others open. To filter to waste the upper right hand and lower left hand valves are open and the others closed.

Many filters have devices such as mechanical stirers or compressed air to agitate the sand during washing.

When a large quantity of water is to be filtered often a "battery" of two or more smaller filters is preferable to one filter of a very large diameter. Such a battery is shown in figure 2. With filters arranged thus one filter can be washed, if desired with filtered water from the other two. The method of operating such a battery is as follows: To filter in multiple the upper and lower valves should be open and the middle ones closed. To wash any one filter the upper and lower valves on the other two should be open and the middle one closed. On the filter to be washed the lower and middle valves should be open and the upper one closed.

Sand filters are very extensively used when filtering is to be done on a large scale. When once installed there is little added expense such as new filtering media, repairs, etc. They have a fairly rapid rate of flow about three gallons per minute per square foot of surface—being a fair average. They are easily washed and have a good bacterial efficiency.

By bacterial efficiency is meant the percentage removal of bacteria during the process of filtering. This figure, however, does not absolutely show the result of filtering. Let water of comparatively few bacteria (50 per cubic centimeter) be taken. A good filtration will probably reduce this to about 7 bacteria per cubic centimeter, resulting in an efficiency of 86

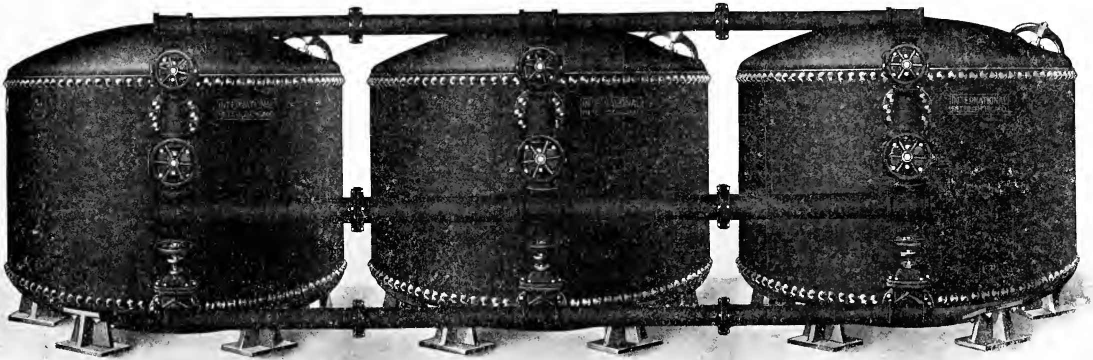

Fig. 2

per cent; with water of 10,000 bacteria per cubic centimeter, the same filter might possibly reduce this number to 200 resulting in a 98 per cent efficiency. Thus it is seen that this percentage efficiency is not an absolute figure representing the work done by the filter but the actual bacterial number should be given.

Charcoal filters are essentially the same as sand filters in construction and operation and differ only in that charcoal is used as a filtering medium instead of sand. This type of filter is preferable in some industries owing to the fact that charcoal possesses the well known properties of absorbing gases and also certain organic coloring matter. One disadvantage rises in the fact that for most efficient operation bacteriologically, the charcoal should occasionally be renewed or removed and baked.

Bacteria have a tendency to collect and multiply in any porous medium and washing does not wholly remedy this as in a sand filter. In a sand filter the various grains are agitated and scour each other thereby removing any adhering action. In charcoal or other porous material this scouring action is absent and therefore baking is necessary.

Stone filters, as their name signifies, employ a stone, porous throughout as the filtering medium. This type of filter, of which there are many on the market, is used extensively as a household filter. The stone is artificially made and is called Tripoli. They are usually made in the form of tubes, either open at both ends, or closed at one end with the same material. These tubes, the size and number of which vary according to the capacity of the filter, are placed in a water tight jacket. The hollow portions of the tubes are connected with the discharge pipe. The water entering the water tight jacket under pressure is forced through the porous stone, the liquid passing through and the suspended matter being retained on the outer surface of the stone. Different types have this order reversed, the liquid passing from the center of the tube to the outside. Certain types have the center of the tube filled with charcoal as an additional filtering element.

Cleaning is effected by brushing away the outer portion of the tube with stiff brushes as soon as it becomes clogged. To

clean certain types it is necessary to take the filter apart while others have brushes the length of the tube, and cleaning is accomplished by rotating the tubes against these brushes. To thoroughly clean them, however, it is necessary to remove the elements and bake them sufficient to kill all bacteria and spores. There is a tendency for bacteria to breed in these stones and unless these are killed by baking, the bacterial efficiency may be low, nil or even negative. So while a filter of this type may produce a clear sparkling liquid, the effluent may possibly be no more pure bacteriologically than the applied liquid and there is even the possibility that it might be more contaminated.

The pulp type of filters differs greatly from any of the aforementioned types. The filtering medium used is pulp, which seems to satisfy requirements in certain industries. The filters consist of a number of filtering elements, each with a small filtering surface but the whole representing a filter of large filter surface. The various makes differ slightly as to construction but all are fundamentally of the following principle: Distributing plates and collecting plates are placed alternately with layers of pulp between. The whole is packed or compressed in a packing arrangement and the filter is ready for use. The liquid is distributed over the different surfaces of pulp by means of the distributing plates. It is filtered in passing through the pulp and is collected by the collecting plates which discharge it into a central receiving pipe. The various types differ in the construction of the distributing and collecting plates and in the manner of feeding the liquid to the distributing plates.

The filter is cleaned by removing the pulp and washing it, after which it may be used again. The filter seems to be especially adapted to the filtering of wines and other liquors, very effectively removing the "mist" or "fog" which so detracts from its sparkling appearance. Another advantage lies in the fact that what seems to be a small filter has a very large filtering surface and hence a very large capacity. However, extreme care must be taken in packing the filter so that

the pulp is evenly distributed and is pressed to just the right pressure.

A type somewhat similar to the pulp filter is the filter press, in that distributing and collecting plates composing a number of individual filtering elements are used. These distributing and collecting plates are placed alternately in a horizon-

Fig. 3

tal rack with paper or cloths between every two plates. The whole is pressed very tightly to prevent side filtration as much as possible. The liquid is fed to the distributing plates by openings, leading from the intake through the various plates. The distributing plate is so constructed that the liquid is fed

over the entire surface from this opening. Sometimes this plate is simply a border of metal and is completely open in the center. The liquid is forced through the filter paper or cloth into the collecting plates which lead to one central outlet, or allows the liquid to be drawn off into a receiving trough by means of drain cocks.

The filters are cleaned by taking out the different units and washing off the residue. The cloths are washed and are then ready to be used again.

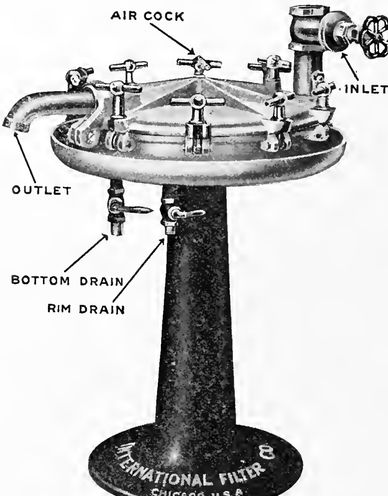

Fig. 4

This style of filter has a great capacity and has been used for years, giving satisfaction.

The last filter to be mentioned is perhaps the simplest and yet a highly efficient filter. This is what is known in trade as the "International" filter. (See figures 3 and 4.)

The filter consists of an upper and lower shelf erected upon a suitable stand. A perforated screen fastened to each shell where they fit together affords a seat for the filter paper or

cloth. The upper shell is then tightly clamped down by means of eye bolts and projecting lugs.

The applied liquid enters at the bottom as shown in figure 4 and under a sufficient lead is forced up througn the filtering medium to the upper shell, which leads to an outlet pipe. The liquid entering the lower shell is forced to travel upwards to be filtered, causing the heavier suspended matter to fall to the bottom therby not clogging the filter so quickly.

The usual method of operating a filter of this type is to place a filter cloth immediately above the lower screen. Above this

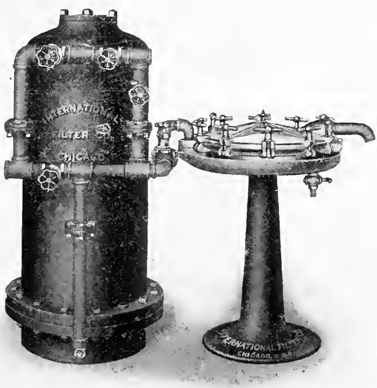

Fig. 5

one or more filter papers are placed, according to the quality of filtration desired. The cover is then clamped down and the filter is ready for operation.

The purpose of the cloth is to retain the greater part of the suspended matter, thus preventing the paper from clogging so quickly. These cloths can be washed and used over and over again while the paper must be discarded when clogged.

A very decided advantage of a filter of this type is in the ease in which it can be cleaned, the whole operation taking but a few minutes. The cover is removed and the clogged

cloth replaced by a clean one. The paper which was immediately next to the cloth is then discarded and the other papers placed in the same order as before. Over this a clean paper is placed and the cover put in position.

Using this method of cleaning the paper which is most clogged is discarded and the liquid must always pass a fresh clean paper immediately before being discharged.

A filter of this type can be put to any of the uses ascribed to other filters. It can be made in any size from a household

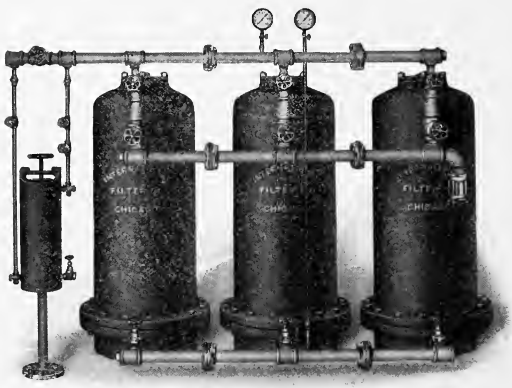

Fig. 6

filter fitted to a faucet up to one delivering hundreds of gallons of liquid per hour.

Owing to the fact that they are used very largely in water filtrations it must necessarily have a high bacterial efficiency. This is accomplished by continually using fresh clean filter paper, which is discarded before any facteria can multiply. Another advantage lies in its adaptability. Any filtering medium can be placed between the screens such as cloth, paper, cotton felt, and even layers of coagulant such as talc, can be placed between the papers for very special work.

The foregoing discussion gives the general characteristics and operation of each type of filter. Ofttimes, however, a combination of two different types is made such as figure 5, showing a sand filter and one of the last named type. The sand filter removes the greater part of suspended matter and the paper filter completes the filtration with a higher degree of filtration.

Figure 6 shows the method of installing the coagulant feeder. The alum pot is connected to the supply pipe as shown with a shunt valve between the two connections. This valve is slightly closed thereby producing a pressure through the alum pot which forces a steady flow of alum solution into the supply pipe, where it reacts with the water. The alum required is very little, so that some contend that this shunt valve is not necessary as the natural diffusion of the alum solution is sufficient for the purpose.

Of course filters are largely used for purifying water supplies. However, they have been found indispensable to liquor manufacturers and bottlers, not to mention dairymen, pharmacists and those engaged in chemical manufacturing. The manufacturers of artificial ice would be helpless without them.

However, their use is now applied to every industry and one is not surprised to know that they have even been employed in such difficult work as the filtration of liquid glue.

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Factory methods to accomplish most, must be supported and executed by a well constructed organization that had best be published to the shop in a chart. This chart should suggest the positons of all persons in the organization, indicate the line of authority through which individuals should report, and keyed with it should be a series of factory instructions, enumerating in detail the function of each position, variance from which should not be made without the consent of the controlling officer.

All authority over plant operation is first vested in the general manager. By affixing his signature to instructions

he delegates portions of that authority to his various heads of departments, but he should place definite limits on the scope of their authority to prevent duplication an doverlapping. For example, the purchasing powers when assigned, should be limited to a specific amount for each account. The manager should establish standards, planned in advance, according to which their operating efficiency will be determined; for instance, the expense permissible in each department should be planned in advance and this allowance should be determined periodically on the basis of anticipated shop output.

All routine work of the business should be taken care of by subordinates in order that the general manager will be relieved of regular details and thereby be able to exercise his keener judgment on the advance planning, in financing the fundamental policies for the development of the company, etc.

The manager and superintendent must not give orders to the same individuals because their orders are bound to differ, further it is not economy to have several persons doing the same thing. On the other hand there should be no duties in the entire plant responsibility for which should not be upon somebody's shoulders.

The superintendent must be skilled in the exercise of his proper supervisory duties and must not be troubled with routine instructions not pertaining to his position; he will then have time to exercise his judgment on such cases as the department heads have not sufficient initiative and authority to act.

In order that the manager may know exactly what is being done, a sufficient number of reports showing the vital figures regarding the business should pass over his desk at scheduled intervals.

The writing of proper specifications for a proposed piece of engineering construction is one of the most important duties of the engineer, but too often is neglected or under-

taken in a haphazard sort of way, resulting in endless difficulties and disputes.

It is generally acknowledged that most of the litigations arising out of engineering contracts is due to faulty and improper specifications, and since it is the business of the engineer to avoid litigation and prevent disputes, he should see to it that his specifications are clear: that they do not demand the impossible: but that they serve both client and contractor alike; protecting the rights and interests of both.

Not all improper specifications are written by inexperienced engineers, but the young and inexperienced engineer is the more likely to encounter this difficulty: partly from inexperience; partly from an over-zealous attempt to protect his employer's interest; but too often the fault of ignorance and a dishonest attempt to cover up such ignorance by so-called "iron-clad" specifications.

It is said that the engineer seeks to protect himself from the dishonest contractor and that his specifications are drawn accordingly. Assuming that the contractor is dishonest, is that sufficient excuse for imposing impossible conditions? If litigation ensues, which it will, will the courts enforce an unfair contract? Will not the engineer be in a better position to protect his own interest and those of his client, if his stipulations are honest and above board, free from the suspicion of unfairness?

It is unfair, however, to assume that the contractor is dishonest. The work that a man does and the reputation that he acquires will follow him and it is unnecessary to let a contract to dishonest and incompetent parties. If such a contract is employed, it is for some ulterior purpose and the suspicion arises that unfair specifications are intended to discourage the honest bidder.

There is a disposition in some quarters to prejudge a contractor as dishonest merely because he is a contractor. Man for man and as a class contractors will average up in honesty with any other business men, but unfair stipulations and conditions may impel to unfair advantages and questionable transactions.

We accord to the butcher, the baker and the candle-stick

maker a proper profit upon their transactions. Why should not the same privilege be given the contractor, who through his business ability, foresight, and handling of men, is able to produce a profit from engineering construction?

In preparing plans and specifications, it is presumed the engineer has a clear mental picture of what he proposes to build, and the drawings and the description should convey a clear understanding and complete knowledge of the work to be performed: the material to be furnished, and should contain all other information necessary to enable a bidder to estimate closely the cost of the work in advance of construction. All this requires upon the part of the engineer, complete familiarity with the subject matter; knowledge of materials; methods of construction; relative cost; standard methods and requirements of tests. It is evident that if through inexperience he is unfamiliar with these, his ideas will be indefinite and he can scarcely hope to carry a clear idea to the mind of another. There, then follows misunderstandings and disputes which proper specifications should prevent. Experienced engineers, however, sometimes fall into error, due to unforeseen contingencies, and plans and specifications that meet with approval in the office may be found lacking in details and definiteness in the field. Under such conditions the engineer should be broad enough to acknowledge the error and make amends in so far as it is possible to do so.

It is probably necessary for the young engineer to copy the specifications of another, but care should be exercised, and every clause carefully examined relative to its fitness for the work in hand. Increased experience should result in increased familiarity with specification writing, and there be no better measure of success in this particular, than from disputes and litigation.

—*Alfred E. Phillips.*

The past decade has witnessed some wonderful advances in chemistry, particularly in the application of chemistry to the solution of industrial problems.

One of the problems which has confronted the chemist for some time, and which has been one of considerable difficulty, is the oxidation of atmospheric nitrogen to produce compounds of nitrogen which may be available for the many purposes to which these compounds are applied.

This problem has been solved not only by one chemist with one method of procedure, but by several chemists with several different methods of procedure.

The method solved by the first investigator in this field was to bring about the oxidation of the nitrogen by subjecting a mixture of nitrogen and oxygen, such as is found in the air, to an electric discharge under certain conditions. The preliminary plant erected to carry out the process as mentioned was constructed by Bradley and Lovejoy at Niagara Falls in 1902. This plant was commercially unsuccessful as the cost of producing nitric acid, the compound desired, was too great. The failure of the plant was not due to wrong chemical assumptions, but to difficulties in securing proper conditions for the action of the electric discharge on the mixture of gases. The ideas of Bradley and Lovejoy were afterwards utilized by a number of European inventors, who were able to overcome the difficulties which made the original process not feasible. Probably the most successful of these European inventors were Birkeland and Eyde. These two men, one a Professor of Physics in the University of Christiana, and the other a Norwegian engineer, so modified the process as proposed by Bradley and Lovejoy, that they were able to reduce the cost of oxidizing nitrogen to a point where the process is commercially successful. They started in 1903 with a small plant having 150 electrical horse power. This has been enlarged until in 1911 they were utilizing 55,000 horse power and with prospects for further increase in the size of this plant. Indeed in November, 1913, the four factories operating under the Birkeland and Eyde patents were utilizing 200,000 horse power and employing about 1,500 men.

Another method for accomplishing the same result has

been worked out by Dr. Otto Schonherr ,one of the Research Chemists with the Badische-Anilin and Sodafabrik.

There is a marked difference in the apparatus employed in the two processes for oxidizing nitrogen, yet the results attained seem to be about the same. At the present time we note a combination of the interests controlling these two processes, and in a single nitrogen works are located furnaces of the Birkeland and Eyde type and furnaces of the Schonherr type to accomplish the same result.

The development along the lines of the oxidation of atmospheric nitrogen bid fairly to nature Norway one of the great chemical manufacturing nations of the world.

The processes previously referred to have as their products nitrous and nitric acid and the salts of these acids. Two German chemists, also associated with the Badische-Anilin Company, developed another process for combining atmospheric nitrogen in such a way that it could be used as a fertilizer, or that the compound obtained could be utilized in the production of other compounds of nitrogen. This result was obtained in an entirely different manner than referred to previously.

Mossian was the first investigator to show that certain carbides, particularly the carbides of the alkaline earths, had the properties of absorbing nitrogen and being transformed to cyanamids. It was some years after Moissan's discoveries were published before practical use was made of them, and a number of indirect methods were tried out before the present direct method was decided upon. At the present time the process of combining atmospheric nitrogen with a carbide consists in first separating the oxygen and nitrogen of the atmosphere by liquifying these gases and subjecting them to fraction distillation. The purified nitrogen is then passed into a drum containing calcium carbide at a temperature of about 1000 degrees C. The calcium carbide absorbs the nitrogen and is changed to calcium cyanamid. This process is carried out in a considerable number of plants, most of them located in different parts of Europe, but some of them located in the United States, Canada, and Japan. In various parts of the world there are about 80 plants utilizing about

400,000 electric horse power to produce about 275,000 tons of cynanamid yearly.

Another process for the utilization of atmospheric nitrogen is that worked out by Haber for the production of ammonia by combining nitrogen and hydrogen. This problem had been worked on by various investigators since 1846. Their results had been of such a character, however, due chiefly to a low yield of product, that the process had been practically given up. Professor T. Haber, however, by a lengthy and exhaustive research in this field, established the conditions which are requisite for the production of ammonia from nitrogen and hydrogen, and this at a price which is commercially feasible. Haber found that when the two gases were brought together in the presence of a catylitic agent, preferably powdered uranium, under a pressure of about 175 atmospheres, and at a temperature of about 500 degrees C., the reaction between the nitrogen and the hydrogen proceeds with such rapidity as to make the process a practical one. The commercial development of this process brought up some commercial problems for the chemists to solve, one of these being the production of a material which would satisfactorily withstand a pressure of about 200 atmospheres at a temperature of 500 degrees C. This problem was solved by the use of a steel of special compositon—being an alloy steel containing vanadium. No factory is in operation as yet producing synthetic ammonia in a commercial way. There will undoubtedly be one in operation, however, before the close of the present year.

Another line of investigation, which has received the attention of the chemist for many years, has been the synthesis of rubber. Commencing in about 1882, we find in the chemical literature the first reference to a synthetic product which is said to resemble in some respects the material we know as rubber. From this time on we find various investigators presenting methods for the synthesis of rubber and making claims that they have been able to produce a material *like* rubber. A close analysis of these claims, however, leads us to believe that they were mistaken in their conclusions and that no rubber had been produced. Through all this mass of

research work, however, runs the idea that isoprene is one of the constituents of rubber, and that by the polymerization of the isoprene molecule, it would be possible to produce rubber. The method of bringing about this polymerization, however, was not satisfactorily discovered until very recently. There are a number of chemists claiming the honor of having first satisfactorily brought about this polymerization. The honor however, seems to belong to Professor C. Harries as the real discoverer of a satisfactory method for the synthesis of rubber.

At the International Congress of Applied Chemistry, held in New York City, September, 1912, Dr. Carl Duisberg of Eberfeld, exhibited a sample of synthetic rubber weighing probably 150 pounds. He also exhibited a pair of automobile tires, the rubber of which was synthetic and which he said had been on an automobile driven over 5,000 miles. There is, however, no factory as yet erected for the manufacture of synthetic rubber. This is due to the present high cost of the materials entering into this synthesis. And it may be that there will never be a factory erected for this purpose, as large quantities of native rubbers are coming on the market from plantation located in the tropical zone.

Practically all of the compounds previously referred to are those which do not ordinarily come under the observation of the layman. We will now refer to some products which are encountered almost daily by every one. First the chemical products used as perfumes and flavors. This is an industry which was practically originated and has been built up in the last ten years. We find very few such materials on the market at the present which do not contain at least some products of the chemical laboratory. Many of these products of the chemist's art are superior to the real products for which they are substitutes. The only objection which can possibly be advanced to their marketing and use, is the one, of the purchaser not receiving just what he thinks he is buying.

Artificial silk is another product which is entering quite generally into commerce. This artificial silk is made by producing a cellulose solution, forming fine threads of this cellulose solution and then rendering the cellulose insoluble.

The "silk" thus produced is spun into thread and then woven into fabric.

You can be reasonably suspicious of any "silk" article offered you which has a high sheen and luster. It is probably made from cellulose or artificial silk. The luster of the artificial silk is much higher than that of the natural silk. It also takes and retains dyes better than those of natural silk. Thus far, however, the artificial silk has lacked the strength which is possessed by the natural product.

A number of industries utilizing oils and fats of various kinds have also been indebted to the research of the chemist. Most of the expensive fats are the solid fats and only the solid fats are suitable for certain purposes as certain uses in cooking and in the manufacture of certain classes and kinds of soaps. Liquid fats are not as suitable, but as many of them are obtained in very large quantities, and as there is no direct market for them in their liquid state, their price is low. The chemist has, therefore, been seeking for a method to change some of these liquid fats into solid fats, which may be utilized in many industries where the liquid fats are not suitable. This problem has been solved by passing hydrogen, in the presence of some catylitic agent, through the liquid fat. Hydrogen changes some of the liquid unsaturated fatty acids to acids of higher molecular weight which are solid.

The proper regulation of the quantity of hydrogen added, will produce a fat of any desired consistency from the liquid fat with which we start through a semi-pasty, and pasty condition to the very solid fat which can be obtained by the complete hydrogenization of the fatty acids. These solid and semi-solid fats are materials which are suitable for many and varied purposes.

We have mentioned many of the most important chemical developments of recent years, but there are many of possibly not so great importance which have not been mentioned. One industry of some importance which has not been mentioned is the product of artificial resinous bodies, which may be used dissolved in suitable solvents for the manufacture of lacquers and varnishes and which in the form of the solid artificial resin may be used for insulating purposes and for articles of

ornamentation and adornment. The college student will possibly be interested in some of these products, as they form a cheap substitute for amber in pipe stems and cigarette holders.

A line of investigation, which has recently yielded satisfactory results, has been the production of metals and alloys which will withstand a high temperature and also metals and alloys which will withstand the action of corrosive agents.

We find in the resistance wire of the tungsten lamp one of the triumphs of the chemist. The first tungsten lamps were made of particles of tungsten fused together making a very brittle wire. The labors of the chemist were extended until finally they were able to produce a ductile tungsten stronger than steel and with a melting point higher than platinum. Our great increase in the use of the electric current in the production of light undoubtedly will date from the production of this ductile tungsten, as the light, per candle power, is produced with much less current consumption and the tungsten filament wears much better than the old carbon filament which it is displacing.

The industries enumerated in this article are by no means all of the important contributions of the chemist to the actual commercial development of the world in recent years. Enough industries have ben mentioned, however, to clearly indicate the important part which the chemist has played in the recent industrial advances of many nations. We venture to predict that the next decade will see as great or even greater industries brought forth as the ones indicated as accomplishments of the past decade.

—*H. McCormack.*

BOOK REVIEW.

STEEL BRIDGE DESIGNING. By M. B. Wells, C.E., Associate Professor of Bridge and Structual Engineering, Armour Institute of Technology. Cloth, 6x9¼ inches; vii, and 260 pages; illustrated in text and 26 folding plates. Chicago, Myron C. Clark Publishing Co.

This book is primarily intended for a college text but the engineer in practice will also find much good material in its

pages. Unlike other books, it is assumed that the reader is familiar with the mathematics taught in Technical Colleges.

It starts out with a chapter on the surveys, the location of the bridge, the position of piers, the determination of span, and all the preliminaries up to and including the letting of the contract. This chapter is followed by one on bridge manufacture and one on rivets and riveting.

Several chapters are devoted to types and details of highway and railroad bridges. These chapters are illustrated with numerous cuts of various floor systems. A roof truss, a riveted truss highway bridge, plate girder bridge, a riveted truss railroad bridge, and a pin connected railroad bridge are completely worked out. A bibliography and valuable data on the weights of various kinds of bridges are included.

To avoid references to books on Strength of Materials, one chapter is given over to the derivation of the principal formulas used in designing. Each formula is illustrated by practical examples, either in chapters on designing or in the chapter on Strength of Materials.

Perhaps the most valuable part of the book consists in the 26 folded plates of Bridge drawings. General drawings and shop details are included. They are examples of the best practice, being, for the most part, reductions of actual drawings by one of the leading railroads of this country.

—*J. C. P.*

ARMOUR INSTITUTE OF TECHNOLOGY BRANCH OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

The third regular meeting of the Armour Institute of Technology branch of the American Society of Mechanical Engineers took place Wednesday evening, December 3, 1913, in the Chapin Hall. The evening was devoted to a paper given by Mr. Joseph Harrington of Harrington and Pebbles, Advisory Engineers. The subject was announced as "The Practical Application of the Theory of Furnace Efficiency." The problems of the boiler room were discussed in minute detail, and the speaker pointed out in particular how the human equation enters into and seriously effects the results. Mr. Harrington said that the only practical means of securing efficiency in the boiler room is in the use of recording apparatus. It is always on the job. However, after all is said and done, it is up to the man in front of the boiler that must carry those things into effect.

The fourth regular meeting took place January 14, 1914, in the Physics Lecture Room. Mr. Fred L. Brewer, '14, presented a paper on "Stanely Steamers." He described every part of the power plant, showing advantages and disadvantages of the steam automobile. After the interesting talk, Mr. Brewer gave the members the privilege to ask questions which he answered in a satisfactory manner.

—*A. N. Koch.*

ARMOUR INSTITUTE OF TECHNOLOGY BRANCH OF THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

The Armour Branch held its first November meeting on the 12th in the Engineering Rooms, Chapin Hall. Mr. A. B. Gates, Engineer for the Sanitary District of Chicago, present-

ed a very instructive paper on "Station Grounds." The lecture was illustrated by means of diagrams and original curves and brought out many profitable points on the location, construction and capacity of grounds.

On November 24, Mr. R. M. Heim and Mr. J. W. Turner of the class of 1914 spoke on the development and construction of "Metalic Filament Lamps." Mr. Heim described this new nitrogen filled tungsten lamp and illustrated his points by showing one of the new lamps in operation. A very lively and interesting discussion followed.

The December meeting of the society was held on the 10th in Science Hall with the members of the evening class as guests. Mr. V. C. Tousley, Chief Electrical Inspector for the City of Chicago, gave an illustrated lecture on "Electrical Inspection." Mr. Tousley touched on the history, the development, and the present activities of his Department and showed conclusively the need of, and the advantages arising from, electrical inspection.

The Annual Midyear banquet was held December 17, at the Boston Oyster House. After a delightful dinner Prof. H. W. Nichols gave a short talk on "Recent Advances in Science."

—*T. C. Bolton.*

CHEMICAL ENGINEERING SOCIETY.

On the 13th of November the society met in the Y. M. C. A. room and at that time voted to change the meeting night to Monday in order to avoid conflicts with the other societies. The feature of the program was a talk by Prof. McCormack concerning his experiences in Industrial Chemistry in connection with commercial work. After this very interesting and helpful talk there was a general discussion of thesis subjects in which Profs. Tibbals, Freud and McMullen gave some valuable suggestions.

One of the best meetings of the year was held November 24th in the Engineering room. Mr. L. A. Hirsh read an interesting paper on "Asphaltic Road Building." Mr. Hirsh did

considerable work along this line during the summer and consequently had many interesting samples and photographs. Professor Freud gave a mighty good talk on "The Industry That Failed," giving an account of his personal connection with the subject and showing the possibilities in putting up a good strong bluff. Mr. A. N. Grossman concluded the program with a talk on "Hospital Chemistry."

The last meeting before the holidays was held December 8th in the Engineering room. After a short business meeting the program was carried on. Messrs. Agazim, Lesser and Shakman related their experiences in connection with the By-Product Coke Co., at which place they worked during the summer. After these talks the evening was passed by consuming the light refreshments which had been provided.

The first banquet of the society was held in the Savage Room of Kuntz-Remmlers on Friday night, January 23rd. The principal speaker of the evening was Dr. Gudeman, who spoke on "Food Law Administration." There was a good turnout and every one was well repaid for going.

The members of the society take this means of expressing their regret at the resignation of Mr. McMullen, who has always been an active worker in the Chemical Department and who holds a large place in the hearts of the students. However, we wish him all possible success in his new undertaking.

—*F. Hook.*

CIVIL ENGINEERING SOCIETY.

Since the last issue of the ENGINEER the Civil Society has held two regular meetings, each being featured by talent from the ranks of the student. At the meeting held in the engineering rooms Tuesday, November 17, 1913, Mr. Kneupfer and Mr. Vesely gave illustrated talks on "The Lockport Power Development." They took up the various phases of the plant, including the detail of construction, the commercial end and also told of some of the political difficulties encountered in a project of this nature. Mr. Penn added a few very instructive remarks.

The next meeting came on December 2, 1913, and Mr. Hirsch of the chemical department presented a paper on "Asphalt Pavements" which proved to be very interesting to the senior civils, who were then studying that subject. Mr. Hirsch spent last summer testing asphalt and is now working along that line for his thesis. That he has given this subject careful and detailed study was evident from the logical and thorough way in which he handled it. Those who were present at both meetings are quite convinced that it is not necessary to always get an "outsider" in order to have interesting talk.

Our next meeting will be held in the engineering rooms, Tuesday, February 3, 1914. The order of business will be: Election of officers, followed by a smoker and a good time. Alumni are invited.

—*E. G. Zack.*

Alumni Department

FOREWORD.

The voluntary assuming of a responsibility that will result in accomplishing any worthy act, is recognized as indicating *character* in an individual or group of individuals. We have tried to give our association a *character* through our Scholarship Fund and the present contract with *The Armour Engineer*. Previous to a few years ago, the only benefit in belonging to the association was the right to "mix" with the old friends at two banquets each year. While it is true that our small dues hardly entitle a person to more than that and while it is equally true that the entertainment received was sufficient, we now feel that we have placed the association on a stronger and more permanent foundation. Our two banquets each year will continue to be spent in having a good time with interesting and well-known men to address us on some live topic. We must have a full membership to be representative and strong enough to carry out our plans and the Board of Managers hopes that the increase in attendance at the past few banquets will continue and that the present spirit of co-operation will result in a doubling of our permanent membership. Will you be a "Booster."

The Board of Managers also takes this opportunity of thanking that Armour classmate who so kindly contributed $50.00 to the Scholarship Fund as announced later in this issue. Could anything be better proof of our statement above regarding a *character* of our association.

THE MID-WINTER BANQUET.

Time, December 19, 1913. Place, Hotel LaSalle. Attendance, 118, breaking all records for winter banquet. That's

the story in a nutshell, for when that many alumni get together they are sure to have a good time. Maybe it was the new tariff law or the promise of ready money under the new currency bill, but more likely it was due to Clausen-Banning, Pavey-Heuchling, etc., for those fellows certainly worked. There was plenty of good fun, good food and a good talk by Mr. Wacker. Only six of the classes reported less than 20 per cent attendance and fine showing made by '99 was properly rewarded after a lengthy "spiel" by Chairman Banning of the Booster's Committee. Each member of that famous class received a handsome present and while some of them wouldn't run, those valuable tokens will, no doubt, be handed down to future generations to be analized and finally broken up like the rest of the Christmas toys.

Under the inspiring leadership of Taussig, we were all singing most of the time with the usual result that our meat became cold and the ice cream melted. Then some class would feel the inspiration a little stronger and let out a class yell, naturally making nearly all the other classes so jealous that a round of yells would result.

After the feed, Mr. Charles H. Wacker, the "man behind" the "Chicago Plan," or as originally called "Chicago Beautiful," gave a very instructive and interesting talk on the possibilities of development of our own city of Chicago. By means of a large number of lantern slides, we were shown what other cities have done and what can be done here and everyone present went away convinced that a comprehensive plan, backed by the knowledge and enthusiasm ot men like Mr. Wacker, is the real salvation of any large city.

Our old fellow alumnus, Professor E. H. Freeman, gave us an idea of the work being carried on at the Institute. President Clausen called for an option of those present as to where to hold the next banquet and the majority wanted it at the Institute again, the same as last spring. The passing out of the prizes for attendance to '99 seemed about to precipitate a riot, so President Clausen wisely called the meeting adjourned.

SCHOLARSHIP FUND.

Chairman Hiller, of the committee in charge of this fund, reports a steady increase in life membership, there now being a total of 36 who have paid up. Sixteen came in last year and it is hoped that we will add at least twenty-five this year.

Few men realize what they are *getting and giving* when they secure a life membership. For twenty dollars they are exempt from the payment of further dues and this money is loaned to students at the Institute at 5 per cent interest. This interest goes back to the general treasury of the alumni association and in this way the annual dues of one dollar are provided for. All of the money in the fund is continually out at interest, under the direction of the officials of the Institute and there is a demand for much more than we have on hand. The way in which this money assists students to get through college should be a sufficient reason to bring every graduate into the fold as a life member, but the added benefit of having your dues taken care of for all time and the fact that this payment brings *The Armour Engineer* without charge as long as the present arrangment exists between the Board of Managers and this publication, will, we hope, be sufficient arguments to bring the total up to 100 in a few years. Just send the money to E. F. Hiller, chairman, 4533 Ellis Avenue, Chicago, and have the satisfaction that will surely come from such action.

The class of 1906 leads the list with eleven life members, with 1899 second with five, 1905 third with four, 1902, 1903, 1904, 1907 and 1911 each having two in the charmed circle, 1900, 1901 and 1909 each have one member and with Deans Monin and Raymond, this brings the total to thirty-six. There are nine members from each of the following courses: Civil engineering, mechanical engineering and electrical engineering; four are chemical engineers and two are architects.

The above figures are from Chairman Hiller's report and he has a very pleasant announcement to make referring to our first contribution. An Armour Academy graduate who went to "Tech" for one year sends in fifty dollars with the request that his name be unmentioned and the particularly fine part

of his gift lies in the fact that unfortunately he is not eligible to be a member of the association. There are probably many other Armour men who have been fortunate in their accumulations, who would like to help their Alma Mater and this cause surely affords an opportunity of showing their gratitude to the Institution that made their success possible.

THE BOOSTER COMMITTEE.

The chairman of the Booster Committee is very desirous of inspiring a spirit of co-operation among all the alumni for the purpose of building up the membership of the association, and for the purpose of insuring a large and enthusiastic attendance at the annual spring banquet and meeting next spring. The constitution of the association does not make provision for a Booster Committee having official powers, and the formation and functions of this committee are largely a matter of convenience and usage. In order to give the membership of the committee a certain official standing, and in order to assist the Board of Managers in the selection of the committee, a departure was inaugurated at the midwinter meeting, in that each class was called upon to select one of its members to be a member of the Booster Committee until the forthcoming spring meeting. The permanent committee will be composed of the members so selected, being one from each class and each permanent member may call in such outside assistance from his class as may be expedient or necessary in order to properly carry forward the Booster work. It is earnestly hoped and believed that this arrangement will overcome certain objections which have been raised to the organization of this committee in the past. In the first place, the membership of the permanent committee from now on will be the selection of the individual classes themselves so that the membership of each class will have an acquaintance with, and knowledge of, the permanent member from its particular class which cannot be assured when all of the members are arbitrarily selected by one or two persons not having a wide acquaintance among the membership of each one of

the seventeen classes which have graduated since the organiation of the Institute. Also the selections of the permanent members in the above manner will inspire in the membership of each class a feeling of participation in the work of the Booster Committee and in the work of the association, akin to a feeling of home rule, which should go a long way toward increasing the enthusiastic co-operation which we most earnestly desire. Only when we can bring the entire membership of the association into harmonious co-operation will we be able to bring into action that feeling, not only of *enthusiasm,* but also af *responsibility* which is urgently needed in order to obtain the biggest and most lasting success of the Association and all that it stands for to Armour Institute, and to Armour men.

In order to inaugurate the foregoing departure, selections were made by the several class memberships present at the midwinter meeting, as follows:

1897........................C. T. Malcalmson.
1898........................E. H. Naglestock.
1899........................Ray S. Huey.
1900........................W. T. Dean.
1901........................F. H. Bernhard.
1902........................A. H. Anderson.
1903........................F. R. Babcock.
1904........................H. W. Clausen.
1905........................C. J. Carroll.
1906........................A. L. Carr.
1907........................S. V. James.
1908........................W. G. Wuehrmann.
1909........................T. W. Simpson.
1910........................M. A. Smith, Jr.
1911........................G. B. James.
1912........................L. D. Kiley.
1913........................A. C. Cramer.

In several cases the classes failed to report selections and in such cases the members designated above were chosen in the old way but it is believed that at the spring meeting full selections will be made in the manner above outlined, and that from that time forward the arrangement will work

smoothly, and that from now on the attendance at meetings will show a rapid and permanent growth. The members designated above will hold office until the spring meeting, when the permanent committee will be selected to hold office for the ensuing year.

The chairman of the Booster Committee, T. A. Banning, Jr., will call a meeting of the permanent committee in the very near future to outline the work to be pursued during the next few months, and the members of the permanent committee are urgently requested to attend such meeting. Let's *get together and push* this work until the Alumni Association becomes a power in Institute affairs.

Another departure inaugurated at the midwinter meeting was the awarding of a personal SOUVENIR or PRIZE to each member present from that class having the largest percentage present of its total membership residing within a hundred miles of Chicago. The deBeers loving cup is given at the spring meeting to the winning class as a class, but this new departure ensures a **PRIZE** to each member of the winning class. (O YOU PRIZE.)

The percentages present from the classes were as follows:

1897	18%	1906	20%
1898	0%	1907	20%
1899	46%	1908	21%
1900	17%	1909	21%
1901	25%	1910	13%
1902	29%	1911	22%
1903	30%	1912	17%
1904	5%	1913	24%
1905	32%		

Accordingly the PRIZES went to "ninety-nine," showing that the boys who gradutaed back in the good old days are still able to sit up and take nourishment, particularly when the nourishment is in the form of the midwinter banquet. They certainly deserve to be congratulated, and particularly PAVEY.

Now we are going to get together and have a record-breaker next time if it takes a leg, but we must have *your co-operation,* so get busy. If you have any kicks to make, make them to the chairman of the Booster Committee, get them out of your system. If you do not have any kicks to make, then co-operate with us, we need *your assistance* and we are going out after it as soon as we find out who you are, so that we can get in touch with you. You are EX-OFFICIO a PERMANENT MEMBER OF THE BOOSTER COMMITTEE from this time on and we expect every member of the committee, both ACTIVE and EX-OFFICIO to DO HIS DUTY towards furthering the interests of the association.

—*Thomas A. Banning, Jr., Chairman of Booster Committee.*

LIST OF THOSE PRESENT AT MIDWINTER BANQUET, DECEMBER 19, 1913.

Anderson, A. H.
Beckman, H. E.
Beifeld, H.
Bernhard, F. H.
Bischof, J. H.
Bornstein, H.
Babcock, F. R.
Banning, T. A.
Banta, J. S.
Bears, W. P.
Beerbaum, A. J.
Boehmer, A. H.
Bradford, J. D.
Busse, C. F.
Carr, H. L.
Canman, E. L.
Clarke, F.
Carroll, C. J.
Chapman, A. B.
Clausen, H. W.
Cooper, H.
Cramer, A. C.
deBeers, F. M.
Dean, W. T.
Dean, W. H.
Dewalt, E.
Douthitt, M. J.
Downton, E. G.
Drozeski, D. H.
Durr, H. A.
Erickson,O. R.
Fors, A. F.
Fry, A. J.
Faulkner, C. D.
Fenn, J. G.
Fornhof, C. H.

Freeman, E. H.
Gillette, E. F.
Goldberg, I.
Goodhue, A. H.
Greifenhagen, E. D.
Greifenhagen, P. F.
Guerin, James.
Harris, R. B.
Hayes, J. J.
Hepp, Arnold.
Hansen, H. J.
Heuchling, F. G.
Holcomb, C. S.
Holden, E. C.
Houghton, Vaughn.
Huey, R. S.
Jarvis, B. H.
Jacobson, J. H.
James, S. V.
James, G. B.
Johnson R. W.
Kloman, R. G.
Kaiser, E. D.
Kellner, W. A.
Kiley, L. D.
Kuehn, H. R.
Leichenko, P. M.
Lohse, A. C.
Lichtner, W. O.
Larson, C. M.
Lewis, R. L.
Malcalmson, C. T.
Marx, W. L.
Martin, W. J.
McCague, J. A.
Mitchell, J. C.
Morrison, R. A.
Newman, I.
Newhouse, A. M.
Ostergren, H.
Pavey, W. B.
Penn, J. C.
Putt, F. A.
Peterson, I.
Petty, E. W.
Porter, L. I.
Rylander, P. N.
Rothwell, R. F.
Richardson, J. R.
Rice, R. H.
Robinson, R. H.
Rosenthal, H.
Sanford, T. H.
Schmidt, E. J.
Schroeder, C. B.
Shimizu, H. S.
Stewart, J. L.
Steindler, J.
Smith, M. A.
Smith, E. J.
Simpson, T. M.
Sherwin, E. B.
Sieck, H.
Sieck, W.
Snow, J. E.
Spitzglass, J. M.
Stadeker, G. J.
Strale, N. W.
Swift, J. B.
Taussig, W. S.
Torrance, Ralph.
Trinkaus, W. H.
Wanner, F.
Yorke, W. H.
Libby, E. S.
Turnbull, I. J.
Wagner, Arthur.
VonGunten, O.
Vey, F. E.
VanEtten, F. C.
Wald, M. D.
Wintercorn, I.
Wuehrmann, W. G.

ALUMNI NOTES.

This column can be several pages long if everyone will send in news. Can we count on an item from you for our next issue?

Leonard Lundgren, '04, C. E., has ben transferred from his position of Project Engineer, Philippine service, to become District Engineer, U. S. Forest Service, with headquarters in the Majestic building, Denver. Lundgren was recently certified by the U. S. Civil Service as Hydro-Electric Engineer. His district comprises the national forest in Wyoming, Colorado, New Mexico, Arizona, South Dakota, Kansas, Nebraska, Minnesota and Michigan. He has charge of the conservation work for the government referring to water power and irrigation.

W. F. (Weedie) Hebard, with offices in the Karpen building, Chicago, is a busy man representing the Detroit Hoist and Machine Company, The Canton Culvert Company and electric trucks for the Buda Company.

A. H. Fash, '05, is down south in the cotton seed oil business and the last word he sent up north was an announcement of the arrival of a little Fash.

Among those who signed contracts last fall, agreeing to support a wife, etc., we might mention our old friend, "Gene" Hiller.

H. E. Beckman, '09, reports that "Beck Jr." is ten months old and doing fine.

Fred Clarke, '07, came over from Detroit to attend the feed. He is Division Traffic Engineer for the Michigan State Telephone Company.

Edwin F. Gillette, '06, has recently formed a partnership with Mark M. Levings, another Armour man.

Both the James boys and the two Greifenhagens were on hand.

We cannot print what Kiley, '12, placed on his card, but we would suggest that he keep posted, for you never can tell..

And you should have seen those fellows at the door, the volunteers, helping Heuchling separate everyone from his coin. Wanner and "Greif" were there on the job.

Are we going to have another Tech-Alumni baseball game this spring? If you like the idea and would like to play write and tell President Clausen about it. Address, care City Engineers' Office, City of Chicago.

Professor Gebhardt has an '09 Armour man, J. M. Spitzglass, at the head of the Gebhardt Meter Company. Have you received a bulletin about this latest appliance?

Quite a few Armour men are members of the Engineer Corps of the Illinois National Guard. These include H. W. Clausen, '04, sergeant; C. C. Sauer, '06, and E. H. Ellett, Jr., '06, corporals; and extremely high privates as follows: W. H. Dean, '05; A. G. Anderson, '10; J. B. Swift, '01; V. Nicholson, '06; and R. C. Martin, '00. They are all enthusiastic about the training they are receiving from some very efficient officers. Ask Swift where he was hit at the last encampment.

"Bill" Trinkaus, '08, claims that as an engineer he's a fine ball player and vice versa. We'll admit the ball player part, but why so modest "Bill" about the rest.

Anderson, '02, Freeman, '02, Libby, '02, and Penn, '05, all Alumni members, represented the institution at the feed.

J. H. Bischof, '13, is with A. S. Alschuler, '99, architect.

J. B. Bradford, '13, is with H. Koppers Company, Chicago.

A. B. Chapman, Jr., '10, is now with the Chicago Telephone Company.

A. C. Cramer, '13, is drawing his money from the C. M. & St. P. Ry.

L. J. Byrne, '04, is now associated with E. E. Maher, '05, who have the Chicago agencies for the Henry Vogt Machine Company (refrigerating machinery), and the Lea-Courtenay Company (centrifugal pumps). The firm will be known as Mayer & Byrne Company, Otis Bldg., Chicago.

The Board of Managers request all graduates to send in suggestions referring to the next meeting, both as to the place to hold same and ideas as to entertainment. Would a vaudeville show made up of home talent be a good thing and would you work up a stunt for same? Let us hear from you soon.

D. MacKenzie, '98, is at Brisbane, Australia, in charge of construction for Swift & Co., of the new plant of the Australian Meat Export Company., Ltd.

V. Nicholson, '06, is now in charge of Bureau of Streets Laboratory, City of Chicago.

"Sid" James has quit the high flyers and is now with the Underwriters' Laboratories as Associate Engineer, gases and oil department.

We would like to mention the present business addresses of all 1913 graduates, but our space does not permit same. We'll get you all in next year if you are not in the Institute year book.

Charles H. Fornhof, our machine tool instructor, was with us and we hope he will come again.

J. H. Jacobson, '08, is now with the Lake City Electric Construction Company, Chicago.

E. D. Kaiser, '11, was among those present, although he is still located in Rochester, N. Y.

We are inclined to believe the report about Swift, '01, and triplets is rather exaggerated. We await further information.

A. M. Newhouse has left Sargent & Lundy to go with J. B. Hewitt & Co., Chicago.

Frank Putt, '05, reports "one little daughter, named Helen Virginia."

L. A. Sanford is now with the H. Koppers Co., Chicago.

The two 1911 "Siecks" were on hand to bring up the percentage.

The various civic departments of Chicago have a long list of Armour graduates, including W. H. Dean, '05; H. W. Clausen, '04; A. E. Bredlau, '11; M. J. Douthitt, '08; C. O. Dowdell, '07; A. W. Eaton, '08; F. J. Flanagan, '06; T. S. Ford, '06; A. J. Fray, '06; J. Guerin, '08; P. Harrington, '06; W. F. Harvey, '06; E. F. Hiller, '06; R. S. Kloman, '10; W. G. Leinniger, '06; H. Ostergren, '09; J. F. Matthews, Jr., '07; I. Peterson, '09; J. S. Reid, '11; G. B. Robinson, '03; R. H. Salisbury, '10; M. J. Salomon, '11; H. Schoedlich, '06; R. S. Spalding, '06; W. Trinkaus, Jr., '08; F. C. Van Etten, '09; R. A. Wight, '07. There maybe a few additons, but the above is enough for an Armour Club.

T. W. Simpson, '09, is now living in Evanston with his family (youngest 6 mo.). He is superintendent of the Chicago factory of the Hotpoint Electric Heating Company.

F. T. Bangs, former editor of this publication, is now with Pawling & Harnischfeger, Milwaukee manufacturers of cranes. He is, however, located here in Chicago where he will be glad to meet all comers.

We want to keep this column of all changes in occupation of Armour men and interesting personnels. Send in your contributions and help out the Editor.

"Auf Wiedersehn" and that means the next banquet.

W. L. BROCK.

The subject of our portrait this week is one of our trans-Atlantic cousins, who, like many of his compatriots, having become fascinated with aviation, decided to visit England in order to study the subject more thoroughly. Being of a scientific turn of mind, he had taken intense interest in aeronautical matters from the time when he first read of the gliding experiments of Lilienthal and Pilcher. It was May, 1912, that he actually set sail for the Old Country, and, as he will tell you, if you happen to find him in a communicative mood, his idea was to spend a few weeks in England learning to fly a monoplane and then indulge in a little sight-seeing before returning to U. S. A.

On arrival he joined the Deperdussin school at Hendon, and taking things steady he did not secure his "ticket" until August. By that time all his plans with regard to returning to the States had been completely upset, and he found his work here so highly interesting that there was nothing to be done but to stay on and learn still more about it. He therefore arranged in September of last year to join the Deperdussin school as a pilot-instructor, and he remained at that for nearly a year. During that period he flew every machine in the school, but his favorite 'bus was the 35 h. p. Anzani-engined Deperdussin. On this he one day made a trip to Brooklands in a gale which was sufficient to keep all the other pilots, except Gustav Hamel, from venturing aloft. On this machine he also reached 4,300 ft., and descended again in 35 minutes. On the 100 h. p. Deperdussin monoplane he took a passenger up to 7,000 ft. Brock is very fond of

climbing and gliding, and he says that apart from the actual pleasure he gets, so much can be learned about a machine during these manoeuvres. In addition to being thoroughly acquainted with the scientific side of aviation, Brock is a skilled mechanic, and previously to taking up flying was engaged as a designing engineer with one of the largest American Motor Car Companies.—(*The Flight, England.*)

(EDITOR'S NOTE:—Mr. Brock graduated from the Mechanical Engineering Department, Armour Institute of Technology, in 1906.)

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(Signed) F. W. Hook,
Business Manager.

Sworn to and subscribed before me this 24th day of November, 1913.

Julia Beveridge,
Notary Public.

My commission expires Jan. 8, 1918.

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EXPERIMENTS IN HEAT TRANSFERENCE IN FURNACES.

BY MAX SKLOVSKY.*

Generation and Transference of Heat.

In heating by combustion, two processes occur, namely, first the generation of heat energy through oxidation of fuel, and second, the transference of this heat to the materials to be heated. The first process, that of combustion, embodies the methods by which the proper chemical and physical mixtures of oxygen with fuel are obtained. The second, that of heat transference, deals with furnace construction, in which heat energy is transferred most readily from the products of combustion to be heated. These two processes are distinct and may be treated ordinarily independently.

The experiments as described in this paper had been undertaken with the direct object of determining the law of heat transference in metallurgical furnaces, with the ultimate object of determining the method of fuel combustion that would give the best results, both from the standpoint of fuel economy as well as simplicity of mechanism or furnace construction. The furnaces referred to are those classed under forging furnaces or metal heat treating furnaces, such furnaces being usually of such small size that the construction used in large melting furnaces of open hearth type does not apply.

Temperature of Furnaces.

The aim in all metal heating operations is to obtain a temperature in the material with as little fuel as possible and in as short time as possible. The rate of heating, or time element of heating, has for some time been known to be in some way proportional to the temperature of the furnace in which the material is heated. Theoretically, it has been determined

*Class of 1900. Chief Engineer Deere & Company, Moline, Ill.

that heat transference from one body to another is dependent upon the difference in the fourth power of absolute temperatures between bodies, provided that the colder body has such surfaces as to completely absorb, without re-radiation, the heat received from the hotter body. Only to such a body, having a surface similar to that of lamp black and having a surface plane or convex, and not concave, does such law apply. Experiments under government supervision had in a crude way demonstrated that the heat radiation of a coal burning furnace through its walls follows the law of the fourth power of absolute temperatures. What actually happens, however, in a metallurgical furnace where the metal heated has not the property above described, that of having a non-reflecting surface, has not been made known by those who may have made experiments in such direction.

Experimental Method.

In determining the rate at which one body absorbs heat from another, it is necessary to know definitely the temperature at every instant of the two bodies. By placing a piece of steel into a furnace the steel commences to absorb heat at a certain rate. This rate diminishes as the temperature of the steel increases. To determine, therefore, the absorption to any particular interval the following method was adopted:

The experiments consisted in placing bodies of steel successively into a furnace for different periods of time, and measuring the heat absorbed during such intervals. To simplify the experiments and to reduce the errors, steel balls were chosen, all of as nearly uniform diameter and weight as could be ordinarily secured. The object of choosing steel balls or spherical bodies was to minimize the effect on conduction of heat at the point of rest, spherical bodies having the minimum area contact. The heat that steel balls could receive, therefore, was mainly through radiation from the walls of the furnace and through contact with the gases. Spherical bodies also heat most uniformly as such bodies have no projecting corners. To obtain a uniform surface, the balls were all preheated to obtain the ordinary black oxide. To further simplify

the experiments and obtain more accurate results the furnaces chosen for the work were,

(*a*) Of such size that the one pound steel balls were practically insignificant compared with the weight of the heated body of the furnace, that is furnaces having over 1,000 pounds of incandescent brick within them, and on this basis the same would have nearly 2,000 times as much heat as the ball would contain at the highest temperature that could be reached within the furnace.

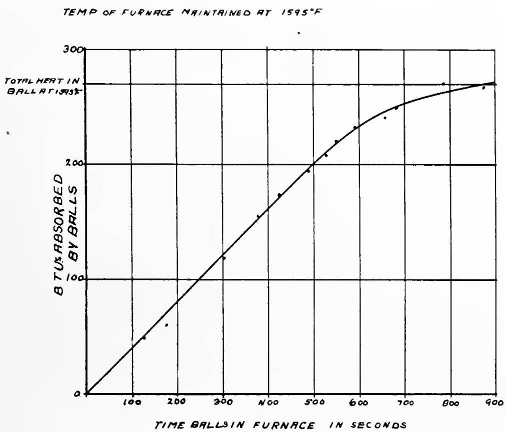


Fig. 1

(*b*) The furnaces were heated for several hours in advance, that is until a uniform temperature was obtained and maintained

(*c*) The type of furnaces used in the first three of the experiments were muffle furnaces, so that a sweeping of the gases against the steel balls imparted heat but slightly. By this means, the steel balls received practically all of the heat from the radiation of the furnace brick work alone. In the fourth and fifth experiments, tests were made in an oil burning

furnace. The balls were placed in such position that the action of the flame was minimized and in this way also the heat received was practically entirely from radiation of the brick work in the furnace.

In these experiments the balls were mounted on top of individual bricks placed endwise in the furnace so as to hold the balls approximately in the central portion of the furnace. In removing the balls from the furnace, the same was accom-

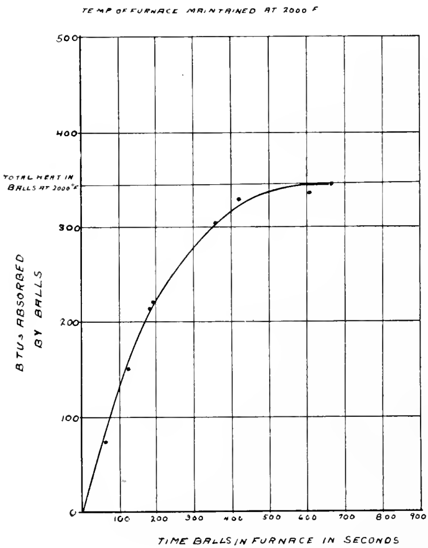


Fig. 2

plished as quickly as possible, so that the loss due to radiation during that interval was minimized. To further minimize eror, the tongs with which the steel balls were handled were preheated so that in grabbing the balls there was very little heat conducted to the tongs.

In all of the above experiments mentioned, furnaces were kept practically closed so that the re-radiation from the steel balls was at all times against the walls of the furnace.

Experiment No. 1.

In this experiment the following apparatus was used:

One gas furnace, muffle type, approximate dimensions of hearth, 30 inches by 60 inches.

One thermo couple and meter for measuring the temperature.

One water calorimeter.

15 nominally one pound steel balls.

No. of Ball	Wt. of Ball
1	1.02 lbs.
2	1.01 lbs.
3	1.02 lbs.
4	1.02 lbs.
5	1.05 lbs.
6	1.02 lbs.
7	1.05 lbs.
8	1.02 lbs.
9	1.02 lbs.
10	1.09 lbs.
11	1.08 lbs.
12	1.08 lbs.
13	1.06 lbs.
14	1.06 lbs.
15	1.06 lbs.

Total weight 15 balls, 15.6 lbs.

The method followed in this experiment, as indicated above, was by placing the balls each for a different period of time into the furnace and measuring the heat absorbed during that period of time by means of a calorimeter. The temperature of the furnace was maintained at 1600 degrees F. as closely as regulation would permit. The results of this test are shown in the curve as plotted in Fig. 1.

Experiment No. 2.

The method followed in this experiment was similar to that of experiment No. 1, except that the higher temperature of

2,000 degrees F. was maintained in the furnace in place of 1,600 degrees F. as in the first experiment. The balls were weighed in advance in each case so that the slight loss due to scaling was corrected for in the calculations. The results of this experiment are shown in the curve in Fig. 2.

Experiment No. 3.

In this experiment a different furnace was used, this fur-

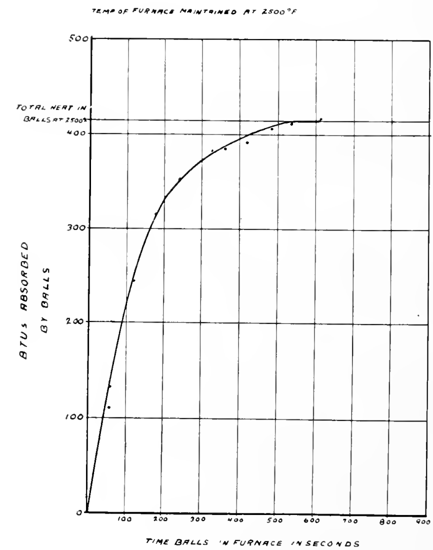


Fig. 3

nace having a hearth approximately 18 inches by 24 inches. The object of using a smaller furnace was this, that the furnace was better adapted to maintain a higher temperature. The method followed in this case was similar to experiments No. 1 and No. 2, with the exception that a temperature of 2,500 degrees F. was maintained. The results of this experiment are shown in Fig. 3.

Experiment No. 4.

With the gas furnaces in experiments 1, 2, and 3, the highest temperature obtainable was approximately 2,500 degrees F. To determine the rate of heat transmission at higher temperatures it was necessary to build a furnace of special construction where fuel oil would be utilized, fuel oil having higher B. T. U. value per pound gave readily higher temperatures

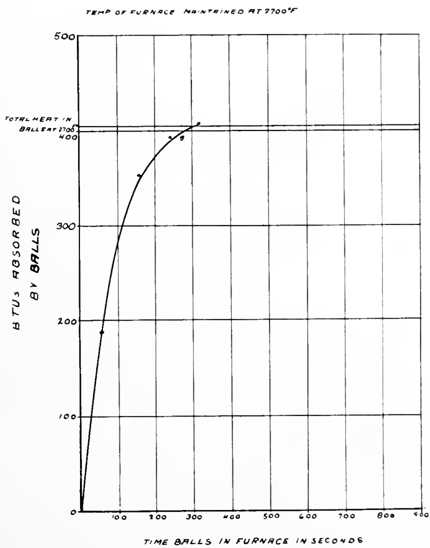


Fig. 4

of furnaces under proper combustion conditions. By special method of burning the oil, flameless combustion was practically maintained, so that the direct heating effect of the gases was minimized. The temperature maintained was 2,700 degrees F. It was necessary also to abandon the use of thermo couples for temperature measurement and to substitute a radiation pyrometer. To check the accuracy of the pyrometer

seger cones and nickel melting point were utilized. The same steel balls were utilized noting before each heat the actual weight, and the same procedure as in the previous tests were followed. The results are as indicated in Fig. 4.

Temperature Calculations.

Curves as per Fig. 1, 2, 3, and 4 indicate merely the heat absorbed in B. T. U.'s in definite intervals of time. In order to establish a relation of heat absorption according to temperature difference it is necessary to translate the B. T. U.'s in

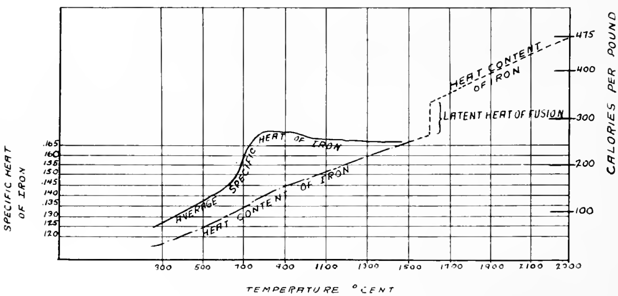


Fig. 5.

each ball into degrees of temperature. The known weight of each ball and the known B. T. U.'s absorbed do not form sufficient facts upon which to calculate temperatures. Were the specific heat of these balls constant, the problem would be simple. Steel, however, as most substances, has an increasing specific heat with temperature rise. This increase in the specific heat value is by no means direct and in the determination of such specific heats some difficulties are encountered owing to the difficulty of measuring heat energy of high temperatures. The most reliable method is that which had been

recently developed with the use of induction electric furnaces. The chart below as shown in Fig. 5 indicates the mean specific heat with different temperatures as obtained from an electric induction furnace where the heat measurement is accomplished with electrical instruments. This curve, as per Fig. 5, was obtained from experiments conducted in induction

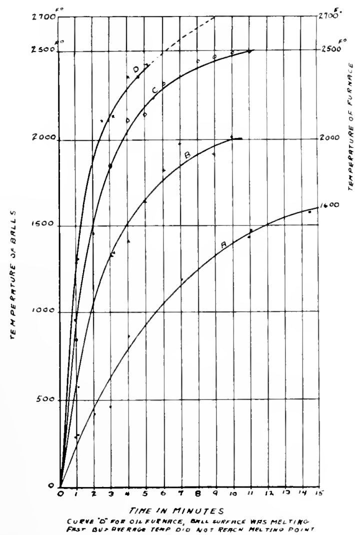


Fig. 6.

furnaces in Germany. The temperature rise of the balls were calculated from the followiing formula:

$$Tr = \frac{B.\ T.\ U.'s}{(Weight)\ (Spec.\ Heat\ at\ Tr)}$$

As Tr, the temperature rise, determines the specific heat, the

trial method was used in making the temperature calculations. Figure 6 shows the results obtained in experiments 1, 2, 3, and 4, with curves showing relation of time to temperature, curves *A, B, C, D,* corresponding respectively to curves in Figures 1, 2, 3, and 4.

The curves shown in Figure 6 indicate very markedly the effect that temperature has upon the rate of absorption or

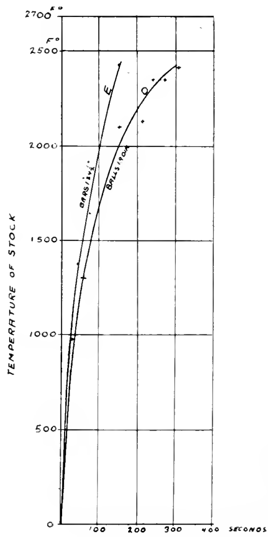
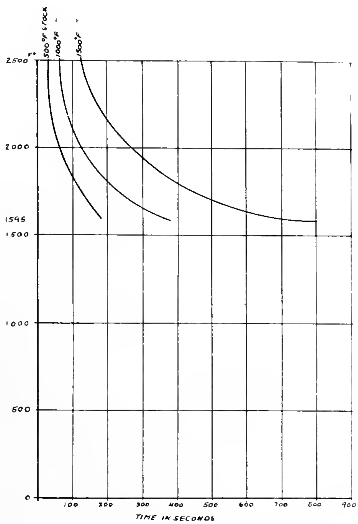


Fig. 7.

transference of heat in a metal heating furnace. It may be noted that in the first test where the temperature of the furnace was maintained at 1,595 degrees F. it took 11.75 minutes for the ball to obtain a temperature of 1,500 degrees F. The same temperature of 1,500 degrees F. was obtained in the furnace of 2,000 degrees F. in 3.8 minutes; in a furnace of 2,500

degrees F. in 2 minutes, and in a furnace of 2,700 degrees F. in 1.25 minutes. In the 2,700 degrees F. furnace it will be noted that the balls had not reached as high a temperature as in the 2,500 degrees F. furnace. In this case the rate of heat transference and absorption was so great that the balls commenced to melt on the outside surface within five minutes. It was therefore necessary to remove same from the furnace



TIME REQUIRED TO HEAT STOCK TO 500-1000-1500°F IN FURNACES AT DIFFERENT TEMPERATURES

Fig. 8.

before the inside of the balls had reached anywheres near that temperature. The calorimeter indicated the mean temperature of the outside of the balls. In the slower heating furnaces the time element being long the maximum temperatures reached were nearly uniform throughout the balls and in all cases below the melting temperature of the balls. In the 2,700 degrees

F. furnace, however, as indicated above, the outside temperature of the balls had melted while the inner temperature remained considerably below the melting temperature. It is likely that the inner temperature of the balls during the time was not over 2,250 degrees F., whereas the outer temperature of the balls, in accordance with the melting point of the steel, was about 2,650 degrees F.

Experiment No. 5.

Fig. 7 shows the rate of heat absorption in a high tempera-

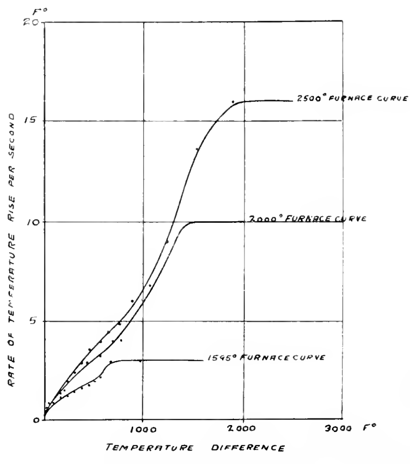


Fig. 9.

ture oil furnace of both the one pound balls and also steel bars 1 inch in diameter by 4½ inches long, also weighing one pound each.

It will be seen that the bars absorbed heat at an appreciable higher rate than the balls. This is accountable from the difference in areas between the two shapes of steel, the bars having a larger area of absorption than the balls. This rate of absorption of the bars is shown experimentally as indicated by the curves, to be greater than the area ratios of the bars and

balls. Particularly is this true at the higher temperatures where the divergence is very marked. This is readily explained by the conductive capacity of the two differently shaped bodies. The balls as evident, have longer distances to transmit, by conduction, the heat to the interior than the bars have. The rate of heat transfer is not only dependent upon the temperature difference and the areas exposed to the radiant heat, but also upon the shape of the body receiving the heat and

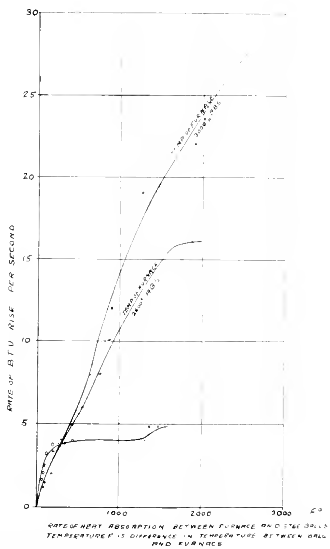


Fig. 10.

upon its conductivity. In large bodies these factors influencing the rate of heat absorption are more marked than in smaller and particularly thinner bodies.

Mass Radiation.

A very remarkable phenomena is indicated in the curves of Fig. 6, curves *A*, *B*, and *C*, showing a rate of heat absorp-

tion that is below the theoretical fourth degree difference in temperatures. Curve *D*, however, indicates that the heat transfer was greater than the fourth power differences or theoretical differences. There is but one way to explain this, namely, as follows: In the lower temperature furnaces, in these tests, the heat absorbed or received by the balls was that of radiation from the brick work of the furnace. This radiation was in accordance with the difference in temperatures and proportional to the incandescent area of the brick work. In

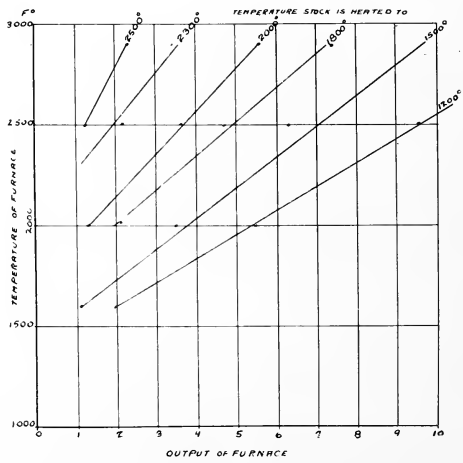


Fig. 11.

the higher temperature furnace, the brick work had obtained such a high temperature that it became transparent to a certain depth and that there is a phenomenon produced that might be termed "mass" radiation, that becomes very marked at extremely high temperatures.

Other experiments undertaken to verify "mass" radiation but which are not sufficiently checked to describe in this paper, seem to indicate that such transparency shows for fire-brick

a penetration to radiant heat for at least one inch of depth, the first 1-16 inch having the greatest transparency to heat radiation. "Mass" radiation in this sense, can be considered as equivalent to multiplying the radiation surfaces, the outer or exposed surfaces having the greatest effect and the effect of the interior surfaces lessened, by their interference of the outward surfaces. At least this phenomena seems present in porous bodies, such as fire-brick. Comparing the curves in Fig. 6, the rate of heat transference at the higher temperatures such as shown in curve *D*, is proportional to

$$T_1^{5\frac{1}{2}} - T_2^{5\frac{1}{2}}$$

which rate is greater than the theoretical

$$T_1^{4} - T_2^{4}$$

Temperature.

Fig. 8 represents three curves which correspond to the three curves *A*, *B*, and *C*, in Fig. 6. The inverse ratio of time to furnace temperature is very marked in these particular curves. Fig. 9 shows the characteristic curve of temperature rise in the same furnaces corresponding to experiments 1, 2, and 3, and to curves *A*, *B*, and *C*, in Fig. 6. Fig. 10 shows the corresponding rate of heat absorption in B. T. U.'s. Fig. 11 shows the range of output for different degrees of temperature of metal under different furnace temperatures. It is remarkable that stock heated to 1,200 degrees F. can be heated 4½ times as rapidly in a furnace temperature of 1,200 degrees F. as in a furnace of 1,600 degrees F. The quantity of fuel used in each case is not shown in these curves. The aim to this point has been to show the remarkable effect that temperature has upon the capacity and rate of heating in metallurgical furnaces. The question of economy enters into the method of furnace construction and method of utilizing fuel.

If for the same amount of fuel a higher temperature in the furnace is obtained, the output is radically increased, in fact, to a greater ratio than the temperature increase is obtained. A regenerative type of furnace is many times more efficient on this account than a plain heating furnace. However, to obtain the best temperatures with the least fuel is a problem aside from the one above indicated, and the solution of this problem has been undertaken in a different set of experiments. There is a theoretical limit as well as a practical limit of

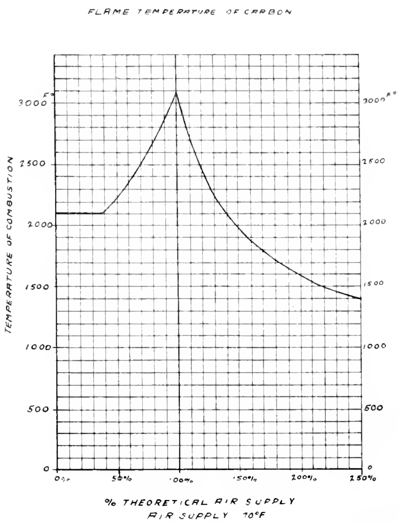


Fig. 12.

temperature that can be obtained. The limits of temperatures are those of:

(1) Intrinsic energy liberated in combustion of different materials.

(2) The specific heat of materials of combustion; and

(3) Upon the ratio of exact chemical and physical combination in the combustion process.

There is a fourth factor entering into temperature, namely,

that what might be termed cumulative temperature, due to the extent of heat imparted to the material of combustion prior to the combustion process. To the above four items, a fifth practical limit is reached by the material of which furnaces are built, refractory material having reached the point of disintegrating, above which temperature it is impractical naturally to operate furnaces.

It must not be assumed in the above that the actual temperature obtainable is largely proportional to the intrinsic energy of a fuel or its B. T. U.'s per pound. By far the most important factor is that indicated in item (3), namely the relative proportion of air with which fuel combines chemically and physically in combustion. The physical combination alone is a very important factor. In the combustion of carbon, Fig. 12 shows clearly the effect air proportion has on temperature.

THE WATERPROOFING OF CONCRETE.

BY ARNOLD PACYNA.*

Cement has become one of the most important factors in building construction, and because of the unavoidable porosity and permeability of this material when made into concrete, a field for water repellants has been created. A material which will make cement or concrete effectively waterproof is in demand.

†"The terms 'Permeability,' 'Absorption,' and 'Dampproof' used in this article need a few words of explanation. A mortar or concrete is impermeable (not necessarily dampproof), as defined and used throughout this article, when it does not permit the passage or flow of water through its pores or voids. The absorption of a mortar or concrete is the property of drawing in or engrossing water into its pores or voids by capillary action or otherwise. If the pores or voids between the grains or particles or in the individual grains, are sufficiently large and connected from surface to surface of the wall, the concrete will be permeable to water. If the pores or voids are very minute but connected one with another, theorectially they may act as capillary tubes, absorbing or drawing in and filling themselves with water, but the capillary forces will tend to hold the water in the pores and will prevent the passage or flow of water, even though one surface of the wall may be exposed to a considerable hydrostatic pressure. For all practical purposes a wall under such conditions would be considered perfectly water-tight and impermeable, although it may be highly absorptive. If these minute pores do act as capillary tubes and are never minute enough to prevent capillary action, the moisture either as water or

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*Class of 1908. Chemical Engineer. The McCormick Waterproof Process Co., Chicago, Ill.

†Bureau of Standards, Bulletin No. 3, pp. 83 and 84.

water vapor would in time penetrate entirely through and fill a concrete wall, no matter what the thickness or composition. In such a case the capillary forces would not permit an actual

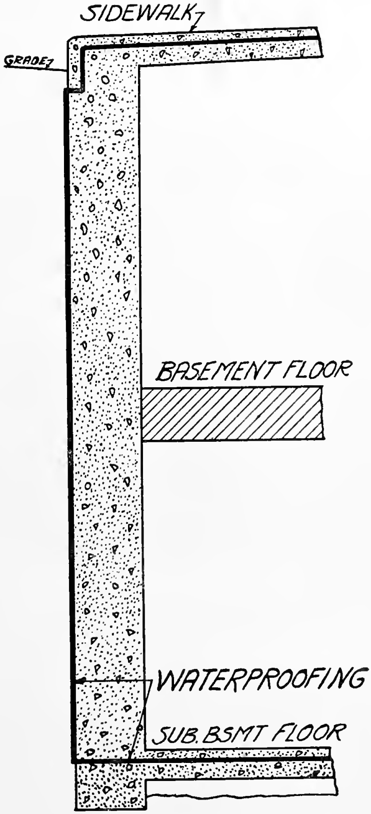

Fig. 1. Method of Waterproofing Concrete.

flow of water, but these forces may carry moisture, entirely filling the wall and unless evaporation is retarded, the opposite face of the wall would appear dry. In such a case the con-

crete would be considered impermeable but not dampproof."

The early architects, and builders used the old system of tar and felt enclosing completely the work in an unbroken envelope of these two materials. This means of waterproofing is to this day a very effective one, but asphalt is used in place of tar or pitch and called the *membrane method of waterproofing*. The greatest caution must be exercised in the selection of the best materials and the most skilled labor. A slight puncture or break in the continuity of the membrane will allow water

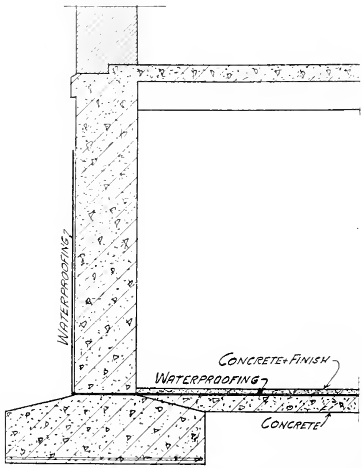

Fig. 2. Method of Waterproofing Concrete.

to get through. It is very difficult to find the exact location of the leak, which is sometimes many feet from the place where water shows on the inside. A properly installed membrane provides for the unavoidable settlement in deep concrete construction by accommodating itself, through its elasticity, to ordinary shrinkage and settlement cracks. The accompanying sketch will explain this method. Under the head of the membrane method we can also include the means used

to waterproof pits or wells in damp localities. This consists of introducing a steel tank as a lining to the concrete work.

Another method of more recent application is the "Drainage-tile Method" used mainly in sub-basements of large buildings. This method requires a pumping discharge system, constant attention and is costly. A trench about a foot wide is dug around the entire foundation retaining wall, down to the level with the lowest sub-basement. In the bottom of this trench are placed open tile, connected at intervals through the wall with a sump or well in the lowest basement. To this sump is connected an automatic ejector pump, or sometimes compressed air is used and the water discharged into the sewer at a higher level. The space above the tile is filled with crushed stone which furnishes a path for the surface water to reach the open tile at the bottom.

When a basement waterproofed by either of the above mentioned systems shows water leaking through, a call is made upon the "Plaster Coat" waterproofing. The usual procedure is to drill holes through the walls or floor and to embed "weep" pipes. This allows the water to come through and the pressure on the wall is relieved. This process is known as "bleeding." The wall is then chipped or roughened and thoroughly cleaned. A wash of cement and water is next applied with a wide brush. Following this treatment comes a coat of mortar made of one part cement (which usually has been waterproofed and will be explained later) and two parts perfect bond. This mortar should be placed without joints, vary according to the hydrostatic pressure on the wall. Sometimes this coat is pounded with flat hammers to obtain a more perfect bond. This mortar should be placed without joints, and well trowled; too much trowling however should be avoided, as this will cause "checking." Within three hours a finishing coat one-eighth inch thick should be applied; when this coat has thoroughly set, the "weep" pipes are capped.

This method is used to make walls dampproof in concrete houses, where it is placed on the outside of the wall, and is then merely a plastering operation. As a precaution to protect against cracks due to settling, or other causes, a bituminous coating on the inside of the wall is advisable.

A FEW WATERPROOFING RESULTS AS REPORTED BY AMERICAN RAILWAY ENGINEERING AND MAINTENANCE OF WAY ASSOCIATION.

Character of Structure.	Material Used.	Results.	Cost.
Roof of Magazine.	Rich mortar plaster.	Not perfect.	Approx. 6c per sq. ft.
Retaining Walls	Asphalt Paint	Can be scratched off.	
Stone and Brick Arch.	Tar Paper and Pitch.	Leaked badly, waterproofing cracked 1 year.	
Reinforced concrete arch.	Anti-Hydrine Damp Proofing.	Leaked badly.	40c per sq. ft.
Dust Line.	3-ply Tar Paper and Pitch.	Unsuccessful expansion caused cracks.	5.91c per sq. ft.
Trough Bridge Floor.	Iron Bark.	Failed.	
Trough Bridge Floor.	4-ply Barret.	Leaks badly 3 years.	
Trough Bridge Floor.	5-ply Hydrex.	Leaks badly 2 years.	
Train Shed Floor.	Mastic.	Cracked and leaks.	
Brick and Tile Wall.	Elaterite.	Cracked and curled 1 year.	1c per sq. ft.
Brick and Tile Wall.	Bay State Cement Coating.	Wore off in 1 year.	30c per 100 s. ft.
Bridge Floor	4-ply Felt and Slag on matched flooring.	Many leaks.	8c per sq. ft.
Bridge Floor	4-ply Burlap and Elaterite on Creosoted Plank.	Failed second winter.	60c per sq. ft.

Approximately 72% of surface coatings reported on were failures.

Integral Method.

The mixture of clay and lime into concrete to increase its density is an old expedient, but, out of this haphazard practise, has arisen a more systematic method called "Integral Waterproofing." By this method the waterproofing material is incorporated throughout the entire mass of concrete. The ultimate aim of this method can be outlined as follows:

First: Not to impair in any way the "set" or strength of cement mortar or concrete. *Second*: To reduce to a minimum the capillary attraction for water as well as the absorptive properties of cement— mortar or concrete.

The integral waterproofing method has been the subject of a great deal of technical discussion, and some elaborate physical and chemical tests have been conducted. Much of these tests and criticisms lead one to believe that integral waterproofing is still in its primary state of development and, like all new and important improvements, it must pass through a cleansing process, whereby all sham and misrepresentation will be eliminated

This method appeals to the builders in that it is a most cheap and expeditious process of obtaining a waterproof wall of concrete On the other hand this method will not compensate for lean mixtures, poor materials or poor workmanship in the fabrication of the concrete; if ordinary care be taken, an impermeable concrete can be obtained. There are three classes of integral waterproofing—Powder, Paste and Liquid. The powders are almost always ground into the cement but some manufacturers advise their introduction directly into the concrete mixture with the aggregate. The paste and liquid are introduced into the tempering water. There are three divisions of the powder variety of integral waterproofing; *first*—"the inert," *second*—"the water-repellant," *third*—"the chemically active."

The table below gives the chemical analysis of a few typical inert fillers.

Primarily these inert materials act as void fillers increasing the density of the concrete; but when they are very finely ground and are incorporated into the cement by a grinding process, (i. e., grinding the two substances together in a pebble mill) we approach the condition of introducing a substance which keeps a small amount of the colloidal cement from precipitating, and thus obtain an impermeable concrete (not however damp-proof).

INERT FILLERS

TABLE NO. 1

* Clays, Sand, Feldspar, Hydrated Lime

	No. 41 N. Y. Clay	No 42 Fire Clay	No. 43 Mo. Clay	No. 44 Feldspar	No. 45 Sand	No 27 Hydrated Lime
Silica..	58.30	52.86	72.91	64.02	89.55	1.34
Alumina.....	16.85	32.36	15.01	19.38	2.36	.45
Ferric oxide	6.41	1.44	2.79	.70	2.58	.13
Maganese oxide	.06	.02	.03	Trace	.12	......
Lime	4.22	.39	.59	.87	1.37	46.90
Magnesia	2.92	.22	.85	.33	.57	32.19
Sulphric anhydride	.12	.10	.12	.10	.21	4.02
Sodium oxide	.77	.21	.80	2.52	.26	......
Potossium oxide	2.71	.43	2.12	11.76	.70	15.05
Water (105°F)	.60	1.69	1.12	.06	.20	......
Ignition loss	7.00	10.49	3.81	.54	2.35	......
Rational analysis	99.96	100.21	100.15	100.28	100.22	100.08
Free Silica	25.56	13.86	43.60			
Clay material	44.29	66.82	29.89			
Felspathic	22.55	7.14	21.58			
Ignition loss	7.60	12.18	4.93			

* 1 Bureau of Standards Bul. No 3 pp 44

This effect is obtained by adding amounts of from three to ten per cent by weight of the cement of these inert materials and they owe their efficiency as waterproofing agents entirely to their finely divided state. The grinding together of the cement and inert materials insures uniform distribution. Rich mixtures of cement and aggregate come under this heading. Recent reports indicate that the larger cement companies are producing a cement into which about fifteen per cent of clayey

material is added in the last grinding Tests from authoritative sources show that a one to three cement mortar in which the cement has been waterproofed by materials of the inert class, has a waterproofing efficiency equal to a one-one mortar in which the cement has not been waterproofed. Time tests show that eventually this one-one mortar will permit water to percolate through it, while ageing does not allow such percolation in waterproofed cement mortar.

It is interesting to note the cost of the two materials. To produce the same results from the above a one-three mortar (one part cement, 3 parts sand) being equal to a one-one mortar not waterproofed (one part cement, one part sand) means that it requires three barrels of plain cement to produce the same result that is obtained with one barrel of waterproofed cement. Cement at a dollar thirty-five cents per barrel would cost according to one manufacturer, two dollars and nine cents per barrel waterproofed; three barrels of plain cement would cost four dollars and five cents. Consequently plain cement, which is claimed to be impermeable, costs twice as much as waterproofed cement.

The water-repelling compounds are a class wherein stearic acid is combined either with soda and potash or lime, and depend upon the fact, as all chemists know, that the lime stearates, or lime soaps, are almost insoluble in water, and are not wet by it, forming the basis of the water-repelling compounds. The greater part of these materials are hydrated lime and the above mentioned inert fillers. The action of these materials is to fill the voids, which will tend to make concrete impermeable, and decrease the absorptive qualities by making the capillary tubes more water-repellant. These materials to be effective must be ground into the cement very thoroughly. A waterproofing material of this character if applied correctly will make concrete water-tight and practically damp-proof. The great cause of failure in the use of these materials is in the joints, where one day's work ends, and the next begins.

The table below gives the chemical analysis of a few typical water-repellant fillers:

TABLE NO. 2

Compound No.——

*	29	30	31	32	33	34	35	36
Silca	3.74	.74	0.59	0.33	1.11	10.22	.43	.32
Alumina	2.23	.62	.42	.19	.37	4.70	1.05	......
Ivon Oxide	.61	.22	.18	.22	.45	.22	.21	.14
Lime	60.55	44.24	44.79	29.86	64.43	43.82	40.75	29.15
Magnesia	.86	29.91	30.54	20.56	.86	.70	26.54	21.07
Sodium Oxide	2.42	Trace	Trace	Trace	2.12	.34	.13	Trace
Potassium Oxide	.46	.00	.00	.00	.23	.70	.41	Trace
Sulph Anhyd	Trace	Trace	Trace	Trace	Trace	1.32	.06	.60
Carbon Dioxide	2.63	4.67	3.20	1.60	2.71	4.21	2.72	1.22
Total Water	18.55	15.90	16.87	9.70	20.48	17.29	23.69	9.01
Parraffin	......	......	......	......	......	......	3.52	......
Fatacids	7.98	3.20	3.30	37.73	6.99	16.20	.64	38.91
	100.03	99.50	99.89	100.19	99.75	99.72	100.15	100.40
Fatacids								
Melting Point °C.	53.00	46.0	43.0	57.5	54.5	55.0	......	56.1
Comb. Weight	256.0	278.00	233.00	276.00	272.00	256.0	......	258.0
Iodine Figure	2.21	Trace	Trace	2.10	1.00	......	......	......

* Bureau of Standards Bul. No. 3 pp. 46

This material for waterproofing concrete of the approximate composition given below,

Aluminum Silicate	
Silica	
Iron Oxide	
Zinc Oxide	92 per cent
Magnesia	Trace
Calcium	
Gelatinous Distributer	7.4 per cent
Moisture	0.6 per cent

was used to waterproof fifty thousand barrels of cement on a large engineering work in Chicago, Ill.

Tests made under the writer's observation by a well known engineering firm on this material are given below.

The manufacturers of this waterprofing specifically state in their directions that it must be ground into the cement in a pebble mill to be effective.

Active Compounds.

This class of materials are usually soaps of stearic acid and sodium or potassium or resinates mixed with a large amount of inert materials and are supposed to react with the lime of the cement to form the insoluble lime stearate or resinate. Their use is attended with a certain amount of risk in that, being soluble in water they are likely to be washed away before any reactions take place, or they are segregated in spots of the concrete work. It is best to use the lime soaps direct ground into the cement to obtain best results.

Construction of Cubes.

Under date of March 15th, we constructed an 18-inch cube of concrete of a mixture of one part of waterproof cement to two parts of torpedo sand to four parts of ¾-inch crushed limestone. In this concrete was embedded a 2-inch pipe.

In the mixing of the concrete the amount of water used was approximately 13 per cent of the total column of the cement, sand and gravel. In order to prevent the cement from flushing up into the pipe, a wooden plug was placed on the inside of the pipe and withdrawn after the concrete had set.

Test of Cube.

After ageing 28 days in air the cube was subjected to test. A test pump was connected to the 2-inch pipe and the hydraulic pressure increased by increments of 50 lbs. Each 50 lb

increment was held for 5 minutes as indicated in the tabulation below:

Pressure lbs. per sq. in.	Time held minutes	Remarks
		Without sign of dampness or leak
50	5	"
100	5	"
150	5	"
200	5	"
250	5	"
300	5	"
350	5	"
400	5	"
450	5	"
500	5	"
550	5	"
600	5	"
800	5	Small sweat leak at end of 5 minutes on the bottom of cube 2 inches from center. Several leaks in bottom of cube in center running in from one side for a length of 12 inches in a straight line. Also one leak on 2 inches from the bottom of cube.

The test was discontinued at this point on account of it being impossible to maintain the pressure due to the small capacity of the test pump.

Ref.—*Robert W. Hunt & Co.*

The following is a report of certain tests on a sample of waterproofed cement in comparison with similar tests on a

sample of Universal cement. The test specimens were made at the same time under identical conditions.

WATERPROOFED CEMENT.

Boiling (soundness) ....O. K.
Per cent fineness on 100 mesh sieve......93.92
Per cent fineness on 200 mesh sieve......77.20
Initial set ....3 hrs. 20 min.
Final set ....6 hrs. 30 min.

TENSILE STRENGTH.

7 day. neat	28 day. neat	7 day. 1-3	28 day. 1-3
595	645	310	349
724	577	297	409
768	746	316	446
661	870	200	357
636	695	335	398

UNIVERSAL CEMENT.

Boiling (soundness) ....O. K.
Per cent fineness on 100 mesh sieve......97.66
Per cent fineness on 200 mesh sieve......82.50
Initial set ....3 hrs. 50 min.
Final set ....6 hrs. 30 min.

TENSILE STRENGTH.

7 day. neat	28 day. neat	7 day. 1-3	28 day. 1-3
669	648	291	412
672	807	320	417
580	743	319	415
643	586	312	350.

Ref.—*Robert W. Hunt & Co.*

Pastes.

These materials are extensively used because of their ease of introduction into the concrete. They are dissolved into the

tempering water, and in this way are made to enter all parts of the concrete. The pastes are packed in cans or barrels and stirred in measured amounts into barrels of water placed near the concrete mixer. These materials are usually emulsions of oils, or are merely soap, and large amounts of lime. A prominent brand of material of this character consists of a mixture of asbestos, china wood oil, and magnesium oxide, and lime, with about sixty per cent of water to form a smooth paste. While in the paste form, this material will produce a milky solution with water. After drying it becomes water repellant and being distributed evenly throughout the entire mass of concrete makes a non-absorbent wall.

Table No. 4.

Compound No. 26.*

	Per cent.
Volatile at 105° (water with less than 0.10 per cent phenol)	93.90
Fat acids (mostly stearic)	.80
Glue	2.10
White Lead	2.11
Lead oxide (litharge)	.94
Sodium Oxide (combined with fat acids as soap)	.03
Potassium Oxide (combined with fat acids as soap)	.05
	99.93

The material is intended to be an emulsion of soap, glue, white lead, water and litharge. It may happen that during the evaporation of the water part of the lead oxide, especially when the litharge is present, combines with the glue to form a

*Bureau of Standards, Bulletin No. 3, pp. 42 and 43.

compound which, after evaporation, dissolves with difficulty.

Compound No. 24.

	Per cent.
Silica	27.27
Alumina	.79
Iron Oxide	.52
Line	23.91
Magnesia	14.02
Sodium Oxide	.26
Potassium Oxide	Trace
Sulphuric Anhydride	1.61
Carbon Dioxide	15.50
Casein	3.19
Glue	8.48
Water	4.82
	99.77

This is a mixture of asbestos, whiting, casein, glue, and possibly a little free or hydrated lime to hold the casein in solution.

Compound No. 16.

	Per cent.
Water	84.99
Ammonia	.23
Petroleum Oil	9.78
Fat Oil	5.00
	100.00

The petroleum oil is a paraffin oil.

Liquids.

Liquid materials are used a great deal for waterprofing concrete because of their ease in handling which consists of pouring measured amounts into the concrete mixer, together with the aggregate. Tests show some very good results are obtained by their use.

Table No. 5.

Liquid Fillers.

Compound No. 38.

Distilloles	Per cent.
Up to 105° (water and ammonia .48 per cent benzol light oils)	2.50
105 to 210° (benzol, light oils; small quantity naphtaline)	3.20
210 to 240° (almost entirely naphthalene)	13.00
240 to 310° (heavy red oils containing a little naphthalene)	20.00
(Residue a very hard brittle pitch)	
Volatile at 105°	30.70
Free carbon	15.00
Ash	.40

This coal tar product the volatile oils having been almost entirely removed. The tar would tend to bind together the particles of the cement and fill the voids.

Compound No. 39.

	Per cent.
Soap	1.05
Oil	47.29
Ash water glass (sodium silicate)	11.64
Volatile (water)	40.02
	100.00

The oil is a very offensive senudrying fish oil: specific gravity at 15 degrees equals .9277; iodine figure 163; soponification equivalent 266; melting point of the fat acids 36.5 degrees c. It is menhaden oil.

A compound made as follows is extensively used by artificial cement stone makers and gives excellent results.

1 pound caustic potash (K O H).

2½ pounds powder alum dissolved in five quarts water to 1 barrel cement (four bags).

At the present day "Integral Waterproofing" is crudely developed, and its functions are neither widely stretched or

understood, and we have consequently a great many materials and a variety of methods for their use. Recent investigations along the lines of initial set of cement and the explanation of the plasticity of clays, may throw some light on the subject.

"The consensus of opinion seems to be that the initial set of cement is due to some action for which the aluminates are responsible or to which they at least contribute in a large measure."—(Journal of Industrial and Engineering Chemistry; May, 1913, p. 369.)

The theory of colloidal chemistry explains still further why this is so according to Dr. W. Ostwald. When cement and aggregate are moistened, colloidal or jelly-like rings are formed. These rings surround the particles of aggregate and overlap each other, and finally these colloidal rings crystalize and form needle like crystals throughout the entire case. This, according to the colloidal chemist, are the initial and final set of cement.

The sumation of all the needle like crystals which enmesh and bind together the particles of concrete is equal to the strength of the concrete. It is a problem in integral waterproofing methods, to introduce some substance into the cement which shall keep a portion of this "colloidal cement" from precipitating, i. e., "A means of keeping slightly soluble salts in solution by uniting the salt ions and form aggregates which do not necessarily precipitate. Finely ground clays are an excellent material for these purposes." (Bureau of Stand., Bul. No. 3.) We readily see why inert materials, such as ground clay, organic soaps, etc., are used for waterproofing purposes.

On page 422, in the May, 1913, issue of the Journal of Industrial and Engineering Chemistry, the following is stated:

"Taking all these facts into consideration, the writer suggests, that the plasticity of clay is due to the presence of an organic compound, (or compounds). This will satisfactorily explain all the important established facts concerning the plasticity of clay. This explains why it is the impure, and not the pure clay which are plastic. This explains why ignition destroys plasticity, and why levigation fails to restore plasticity to the ignited clay. This explains the heretofore

unexplained practice of weathering clay before using it in the ceramic industries. In 1883, Roscoe and Schorlemmer said 'It —is allowed to remain for a considerable length of time, in a moist place, when the organic matter contained in the clay undergoes putrefactive decomposition; this seems to increase the plasticity of the mass, but the exact action which takes place under these circumstances is not well understood.' This explains why shales lose their plasticity on being metamorphosed into slate. This explains the observation of P. Rohland mentioned by Ashley to the effect that plasticity of clay is reduced by all bases and all salts of strong bases with weak acids which hydrolytically split off hydroxy-ions, and that neutral salts have no effect on the plasticity; for the aluminum organic compound observed by the writer is soluble in alkali."

From the above it becomes plain why organic substances are used in integral waterproofing compounds, which are the colloidal or jelly like portion of the cement and tend to fill the voids or small capillary tubes which form when the cement crystalizes. It becomes evident that only a small amount of this organic substance is required for this purpose (about two per cent by weight of the cement) because the colloidal material or organic aluminates increase in volume, and consequently permeate and fill the entire porous concrete material. Unless a portion of raw material is ground with cement, the use of rich cement mixtures will not entirely bring this condition about; and, furthermore, although as apparent waterproofing effect may be obtained by rich cement mixtures, it is not permanent. In the concrete the colloidal substances, although they may dry up, do not lose their property of taking up water and increasing in bulk. The retention of this quality by the coloids or organic aluminates thus makes them efficient waterproofers when water tends to enter the structure. This colloidal substance is able to withstand great hydrostatic pressure as demonstrated by tests shown in another part of this article. Reasoning along these lines the writer has developed and applied for, patents on a process which will be the subject of a later article.

THE MODERN PASSENGER CAR TRUCK.

BY WILLIAM C. BRUBAKER.*

While the automobile has been developing to serve man on the highways of the world, the modern steel passenger car has been paralleling that development on the steel arteries of this land. A span of ten years may be said to cover the active progress manifested in both lines. Symmetrical development is rare in any art or science and the steel passenger car is no exception. As with the tire on the automobile so with the trucks under the railroad car, the earnest efforts expended seem now to promise due returns.

It seemed incongruous to build car bodies of steel and then mount them on trucks of wood reinforced with iron plates. Two solutions of the problem were found; the use of a truck frame of integral design made of cast steel or the "built-up" frame employing structural shapes, plates and pressed forms. Both types have their ardent advocates and both are widely used in varying forms. Except on light weight coaches and baggage cars, the four wheel truck has been largely done away with on account of the heavy journal loads involved and the inferior riding qualities. This discussion will therefore mention that type but briefly.

It is assumed that the system of load distribution in the six wheel truck is understood but a hasty summary may not be amiss. Half (or approximately half) of the weight of the car body is carried by each truck and transferred to the truck center bolster (Fig. 1) through the body and truck center plates. These form the pivots that permit the truck to swing relative to the car body when curves are encountered. Half of this center plate load is transmitted through the center

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*Class of 1906. Foreman, Templet Department, The Pullman Car Company, Chicago.

bolster to each of two cross bolsters or "swing beams," extending transversely of the truck and supported on the elliptic springs, which which in turn rest upon the spring plank. This spring plank is supported at points immediately below the springs by swing hangers pivoted top and bottom in such a manner that the cross bolsters (and therefore the car body) can move in a transverse direction with regard to the tracks, the latitude of this motion being from two to two and one-half inches each side of the normal position . The top pivots of this hanger are in the truck frame and it is apparent that the car body and truck frame are not rigidly fixed in their relation to one another. The car body has freedom to move in all directions except that longitudinal of the car and all play in this direction is kept at a minimum to make the car ride

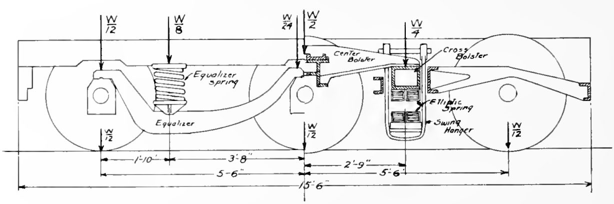

Fig. 1. Distribution of Load.

smoothly and to prevent undesirable slack in the brake system. Vertical movement to the extent of about two and one-half inches is provided for by the elliptic springs.

We have thus far traced the course of the load due to one-eighth of the weight of the car through to the top swing hanger pivots. From these points the load is transmited by the truck frame to the equalizer springs of helical form and to the equalizer. In order that each wheel shall carry the same load (that is, one twelfth the total weight of the car) two-thirds of the load transmitted by the equalizer spring is brought to bear on the end journal box and the remaining one-third from each of the two equalizer springs on the one side of the truck exerts pressure on the center journal box.

This is readily accomplished by placing the equalizer spring at a distance from the end journal equal to one-third of the distance between adjacent journals. We therefore have on each journal and its accompanying wheel, two-thirds of one-eighth or one-twelfth of the weight of the car. The truck frame being thus carried by the equalizer springs of helical type is protected from the destructive minor impacts due to rough track and rail joints; on the other hand, the larger inequalities of the road bed are cut off from the car body by the dampened action of the elliptic springs.

The dimensions of the typical six wheel truck with journals five inches in diameter by nine inches in length are about as follows:

Width over wheel pieces or main side members 6 feet, 8¾ inches.

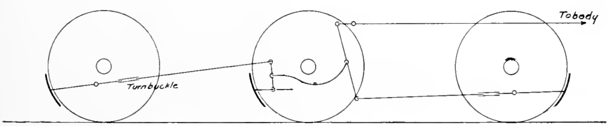

Fig. 2. Triple Brake System.

Length over end sills,15 feet, 6 inches.

Wheel base 11 feet.

Height from rail to top of wheel piece of the completed truck, 3 feet.

Height from rail to center plate, 2 feet, 6 inches.

Gauge of track, 4 feet, 8½ inches.

Wheels (diameter) 3 feet.

Weight, complete, each, 22,000 pounds.

It is but recently that a wheel base of eleven feet has been employed to any great extent as the shorter wheel base of ten feet and six inches is preferable for numerous reasons; but the advent of the "clasp" or "clamp" brake has made the greater length imperative. This will be referred to again and in more detail.

It will be seen therefore that the modern truck is far from

being a toy in either size or weight. These features are not appreciated when the truck is seen under a car because of the overshadowing size of the car itself, many of these being eighty-two feet or more in length over all. Some idea of this solidity may be gained by comparing the trucks with a seven passenger automobile of touring car type. Occupying approximately the same ground space and of a little more than half the height, the trucks will weigh five and one-half times as much as the auto.

From the foregoing, the difficulties involved in making the

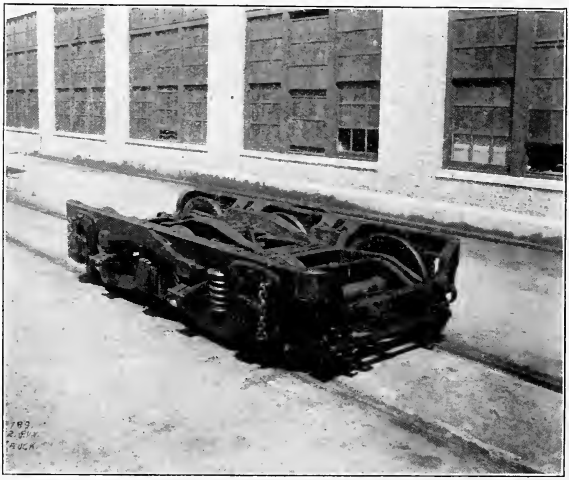

Fig. 3. Cast Steel Truck for Pullman Steel Sleeping Cars.

truck frame of a single steel casting can be readily appreciated; especially when the form of it is considered, the cross members or transoms and end sills being set down below the top of the wheel piece from nine to fourteen inches to clear the carrying girders or center-sills that form the backbone of the car. In addition numerous minor features must be provided for, such as brakehanger brackets, lugs for axle device suspensions, offsets in members for brake lever clearance and swing hanger pivot bearings. Trucks of this cast steel type

have nevertheless been in successful service for more than eight years and credit for this satisfactory design and materials is due the manufacturers, the Commonwealth Steel Company, of St. Louis, Mo. A general view of the truck used under the steel sleeping cars of the Pullman Company is shown in Fig. 3.

The spectre of "crystalization" was called forth with solemn chant when this type was first introduced but experience thus far indicates that there is no substance to this particular ghost. Many have, nevertheless, advocated the built-up truck, of

Fig. 4. Pressed Steel Truck for Atlantic Coast Line Ry.—Built by the Pullman Car Company.

which there are many forms. These may however be divided into two main classes, viz., the truck involving solely structural shapes and flat plates and that composed of pressed steel forms. For the main members—the wheel pieces of the first type, the sections commonly employed are standard eight or nine inch channels, two per wheel piece with the flanges turned inward toward one another, or special ship channels may be used of eight inch depth. In certain instances eight inch I beams are utilized or angles and plates. Such a truck

possessing unique features is described and illustrated in a recent railway magazine.*

An example of a pressed steel plate truck is best illustrated in that designed and built by the Pullman Company for the Atlantic Coast Line Railwayand shown in Figures 4 and 5. All the members of the truck frame are of inverted "U" section of three-eighths, one-half and five-eighths inch material.

While this is not the most economical distribution of the material from the standpoint of theoretical mechanics, practi-

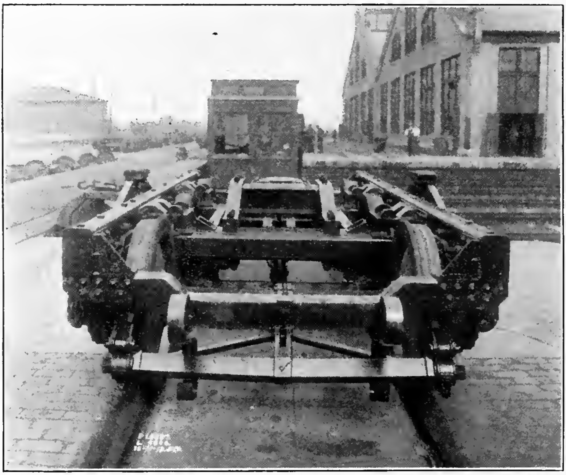

Fig. 5. Pressed Steel Truck for Atlantic Coast Line Ry.—Built by the Pullman Car Company.

cally there are many advantages resulting from such a section, among which may be mentioned the following: a minimum of rivets is required in making connections; the wheel piece being open at the bottom does not have to be coped away or upset at the pedestals to clear the feet of the equalizers as has to be done with structural shapes in most instances; there are very few pockets to catch dirt, ice and snow; the truck is less angular in appearance due to the rounded edges of the pressed

*Railway Age Gazette, Mechanical Edition, January, 1914.

sections. The connections between the transoms or central cross members and the wheel pieces are provided for by compact steel castings which also embody the upper pivot bearings for the swing hangers. The end sills are joined to the wheel pieces by malleable corner connections of ribbed design.

Built-up trucks are lighter in weight than the cast steel ones, weighing from 38,000 to 40,000 pounds per set of two as against 42,000 to 44,000 pounds for the latter. They are also more readily repaired in case of damage by wrecks as the bent or broken parts can be easily cut out, repaired or renewed, and replaced. To straighten out a cast steel frame that is badly damaged and weld the breaks by the oxy-acetylene or electric-arc method is no small task. It may be said on the other hand that the cast steel frame will stand more abuse before bending or breaking than will the average built-up truck. There is also broad ground for the criticism of "too many rivets" in the built-up truck. With the best of workmanship, these rivets in part become loose after a few years of service making this seem an unsatisfactory means of connecting the various parts; less secure than the machined driving-fit bolt so widely used in electric street railway and inter-urban truck design. Why this should be so is not apparent as the truck frame is supported on springs intended to absorb the vibrations and impacts.

So far, nothing has been said with regard to the brake system of the truck and it is in this very important phase of the subject that the greatest interest is now being displayed and most rapid improvement shown. For many years the "triple brake" has given very satisfactory results, but modern heavy cars and high brake power percentages have demanded a re-distribution of the braking forces. In the triple brake system, three brake beams per truck are employed, so arranged that the brake shoes upon their extremities bear against that side of the outer and center pair of wheels, which is nearest the end of the car, and upon the inner side of the inner pair of wheels. These are connected and actuated as shown in Fig. 2.

It is customary in all passenger car brake practice (outside of electric traction work) to apply a total pressure on all the

brake shoes varying from twenty-five to ninety-five per cent of the weight of the car when service application of the brakes is made. When the brakes are set in an emergency application, the pressures are about doubled. For example, with the Westinghouse LN Schedule, eighty per cent of the light weight of the car represents the total pressure on all the brake shoes with an effective brake cylinder pressure of fifty pounds per square inch. When set in emergency, the

Speed at initial point of stop	Data recorded	Units	Total pressure on shoe		
40 mi. 1 hr.			9,000£	12,000£	18,000£
	Mean Coeff Friction	%	19.1	17.4	16.9
60 mi. 1 hr.	Average Wear	£	1.024	0.835	2.207
	M. C. F.	%	14.6	12.3	11.6
80 mi. 1 hr.	A. W.	£	1.026	1.606	2.902
	M. C. F.	%	12.0	9.9	9.6
	A. W.	£	1.918	3.791	6.069

NOTE. Average wear is given in pounds of weight lost per 100,000,000 foot pounds of work done.

Fig. 6. Table-Coeff. of Friction and Average Wear.

cylinder pressure becomes one hundred and five pounds per square inch and the pressure on the shoes is increased two and one-tenth times, or the total pressure on all the shoes is one hundred and sixty per cent of the light weight of the car. By light weight of car is meant double the weight of the lighter of the two ends without any super-imposed load, i. e., passengers or baggage. In private cars or dining cars the weight of the kitchen end often exceeds the weight of the

observation or dining room end respectively by 10,000 to 12,000 pounds. If this were not taken into account, the brake lever or percentage would be five or six per cent higher on the light end than was intended and about the same amount lower on the heavy end. This excess might result in flat wheels due to sliding at the light end.

The pressure exerted on each brake shoe under emergency

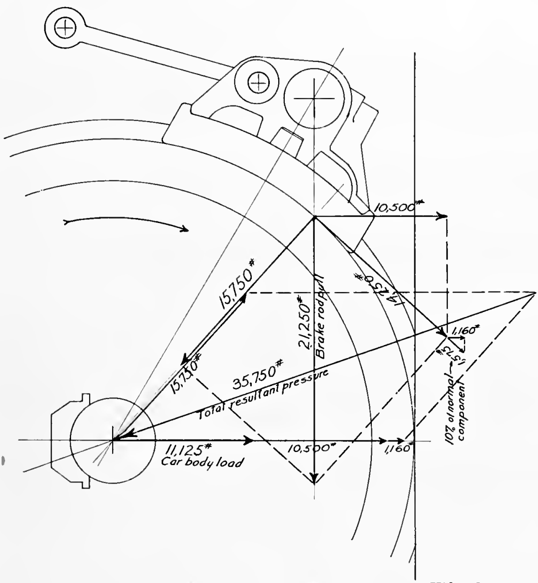

Fig. 7. Analysis of Forces Acting Upon Wheel.

application becomes great enough with a heavy car to destroy the shoe without developing fully its retarding capacity. The coefficient of friction decreases as the pressure and speed increase as shown in the table Fig. 6, where it will be noted that no pressure above 18,000 pounds per shoe are given. Greater pressures have been proven inefficient but they are nevertheless met with in practice. For example under a 170,000 pound

car, the pressure per shoe would be under the conditions stated for LN schedule.

$\frac{168}{100} \times \frac{170{,}000}{12} = 23{,}800$ pounds; a figure thirty-two per cent in excess of that set as the limit after exhaustive tests by a special committee of the Master Car Builders' Association, viz., 18,000 pounds per shoe or 400 pounds per square inch. This is also specified by the Railway Mail Service as the limiting shoe pressure on postal cars.

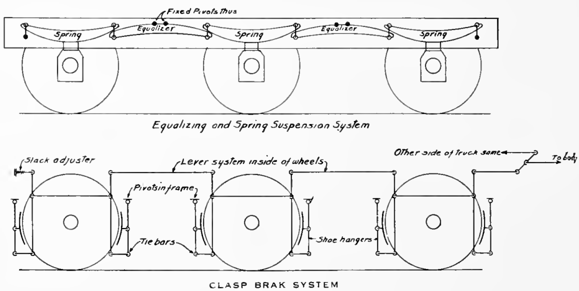

Fig. 8. American Brake Company—Truck of the Commonwealth Steel Company.

There was but one thing to do to correct this condition: more brake shoes had to be employed and anything short of doubling the number seemed but a half-hearted remedy, especially in view of the fact that the tremendous side pressure on bearing and journal box and pedestal could be eliminated by having two shoes per wheel diametrically opposed or nearly so and exerting equal pressures on the wheel. More easily said than done! The number of parts to secure this result is not double the previous number but triple or even more. But fortunately in most of the designs brought forward thus far a goodly number of parts are of the same form in

any one design cutting down the number of dissimilar parts to a reasonable total.

It seemed desirable to incorporate certain features into such a clasp brake design, as follows:

1. Two shoes employed per wheel—the basic idea.

2. The centers of the face of the shoes to be placed but two or three inches below the center line of the wheel instead of eight inches as is often done.

3. Entire elimination of the brake beam; or the use of a tie bar between the brake heads capable of resisting minor bending moments.

4. Easy access to the four inner shoes on each side of the truck by re-modeling the load sustaining members, i. e., equalizers and springs.

5. The transfer of the brake forces from the body system to that in the truck is to be made to occur as near the center plate as possible.

6. Ample allowance to be provided for wear of shoes and wheels without resorting to slack adjusting mechanisms such as turnbuckles.

7. Brake shoes to be hung from the equalizer or some other point on the truck not subject to variation in height.

The advantage to be gained by having double the number of shoes with half the power pressure per shoe may be seen from an inspection of the table, Fig. 6, previously mentioned. The data shown was taken from a fuller report made by the New York Central Lines of tests conducted by that system and recorded in the proceedings of the Master Car Builders Association, Vol 47, Part I, pages 98 to 120. A comparison of the coefficients of friction at pressures of 9,000 and 18,000 pounds per shoe indicate that in general at the same speed the co-efficient is about twenty per cent higher at the lighter pressure. Also the wear of the shoes per one hundred million foot pounds of work done is only from one-third to one-half as great at the lower pressure as that which obtains at the higher pressure. This indicates that the renewal costs are decreased by the clasp brake although double the number of

shoes are required in service over those necessary for the triple brake.

Furthermore the desirability of having the shoes hung high is brought out by the analysis of the forces acting upon the wheel shoe and bearing as seen in Fig. 7. It will be noted that there is a downward tangential component due to the low hanging of the shoe that is at least as great as the vertical pressure on the bearing due to the weight of the car. The shoes are hung from the truck frame and the three forces developed in this manner (one at each wheel) cause the helical equalizer springs to compress solid. This results in the brake shoes traveling in under the wheels producing excessive brake-cylinder travel with consequent loss of power. If the shoes were hung from the equalizers as suggested in Fig. 7, above, these forces would have no effect on the truck frame.

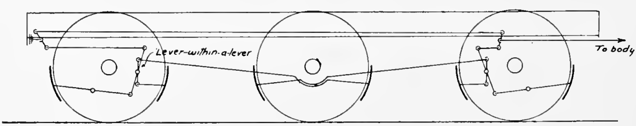

Fig. 9. Clasp Brake System. (The Pullman Company.)

Entire elimination of the brake beams seems desirable on account of the weight involved, the deflection of the beams under load, interference with dynamo pulleys and interference with the elliptic springs. This result seems however, impossible of attainment and the use of a tie bar that will transmit load seems a reasonable compromise.

Such a tie bar is employed on the clasp brake brought out by the American Brake Company and Commonwealth Steel Company, jointly, which also illustrates the accessibility of the inner shoes. The helical equalizer spring has been done away with and a semi-elliptic located in the wheel piece has been substituted for both spring and equalizer, only short equalizers being retained over the journal boxes, Fig. 8. In the clasp brake design followed thus far by the Pullman Com-

pany the equalizer was retained but was made straight across the tops of the boxes instead of being set down. This required that the equalizer spring be set up into the wheel piece which was readily done on the cast steel frame used. The truck brake system employed by that Company may be described as two distinct modified triple brakes on a single truck, each complete in itself. Aside from the straight equalizer already referred to there are two novel features; a lever is incorporated in the outer end sill which reverses the direction of motion of half the brake system; in the second place, a "lever-within-a-lever" is used to economize space and concentrate at one point the functions of both the live and equalizing levers of the triple brake as ordinarily applied, Fig. 9.

We have thus tried in a brief review to bring together a few of the most salient features involved in the design and construction of the modern passenger car trucks, the most interesting and necesary portion of the modern train except the locomotive, which is ahead of all, both literally and figuratively.

THE AUTOMOBILE RADIATOR.

BY K. M. BOBLETT.*

The full meaning of the word, "Production" cannot be realized by the average layman until he has been intimately connected with the autombile industry. Automobile accessory manufacturers have embodied the meaning of the word "Production" and have arranged their plans accordingly.

It is safe to say that the automobile has done more to reduce the cost of all manufacturing and has produced more captains of industry than any other line of machinery.

The object of this paper is to take the automobile radiator as an example of quantity production and to explain the methods which bring about intensive production, of duplicate parts in the plant of the Kinsey Mfg. Co., Toledo, O. It will also endeavor to show reasons for choice of material and methods used.

General Principles of Radiators: The ideal internal combustion engine does not require a radiator, for the reason that the ideal engine is conceived to have a cylinder which will not conduct heat. Practically, this is impossible and some means must be provided to take this heat away from the cylinder walls.

This disposition of heat is accomplished in two general ways. The direct method is to form ribs on the outside of the cylinder and then blow air against these ribs. This method works very well for small motors, such as those used on motorcycles and often on small stationary motors. Air cooling has been repeatedly tried but its failure is shown by the

*Class of 1909. Radiator Expert, The Kinsey Manufacturing Company, Toledo, Ohio.

fact that less than one per cent of the automobiles made are directly air cooled.

The second or indirect method of cooling is the method universal and the one we are most interested in. The indirect method may be subdivided again into two general divisions, that which does not use the water over again—used altogether in stationary gas engine practice; and that which must use the water over again, being used in automobile practice. In

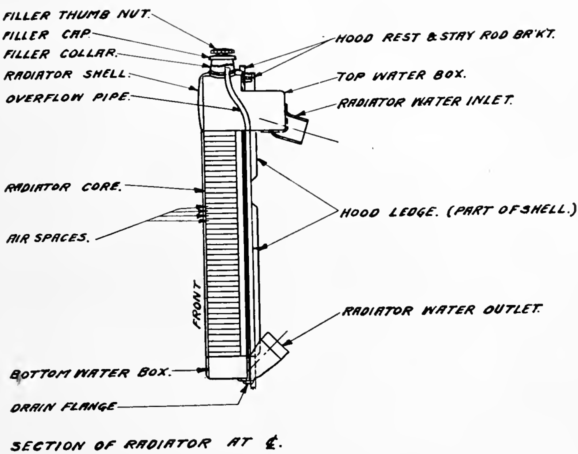

Fig. 1.

stationary gas engine practice the water is the direct method of heat dissipation, but in automobile practice air is the heat dissipating medium, the water simply acting as the carrying agent of the heat.

Air being a rather poor conductor of heat it follows that a highly efficient radiating surface must be presented to the air in order that it will take up heat. The automobile radiator

performs this function, and in so doing must embody the following features if it be an economical success:

Must be efficient.

Must withstand road shocks.

Must be a manufacturing proposition.

Must be light.

Must not clog with mineral waters.

Must not give much wind resistance.

Must be easy to repair.

Must present a pleasing appearance to the eye.

As an example of a modern radiator the writer will use one which he has recently patented, and will also describe the general patented methods for producing this radiator.

Figure 1 is a cross-section of an ordinary radiator, and Fig. 2, a front view of a completed radiator. Referring to Fig. 1, the hot water enters the water inlet from the engine, passes downward from the top water box, through the case, where the air takes up a certain amount of heat. From the case the water enters the bottom box, leaving by the water outlet, and returns to the engine where it again takes up heat.

This cooling water is circulated either by mechanical means, or by the thermo-syphon principle. When circulated mechanically, a water pump is placed between the water outlet of the radiator and the engine, and is driven directly from the engine. On large engines this method is used altogether, because not enough water can be circulated by the thermo-syphon principle. Pump circulation has the disadvantage of circulating the same amount of water irrespective of the temperature of the water and the outside air. An engine equipped with pump circulation is not very efficient in the winter months because it is overcooled, and the engine cannot work at its proper temperature.

The thermo-syphon principle is now being used almost universally on small engines up to a size of a four-cylinder 4⅜-inch bore by 4¾-inch stroke, and a six-cylinder 3¾-inch bore by 4½-inch stroke. Circulation is produced in the thermo-

syphon system of cooling by reason of the difference in weight of hot water and cold water. Again referring to Fig. 1, water at a temperature of about 208 degrees F. enters the top of the radiator, displacing water which has had its temperature lowered in the case or cells of the radiator. As fast as the water in the cells or case cools it drops to the bottom of the radiator causing hot water to be forced up from the walls of the engine. It will be seen that by this system the water surrounding the cylinders will always have a temperature

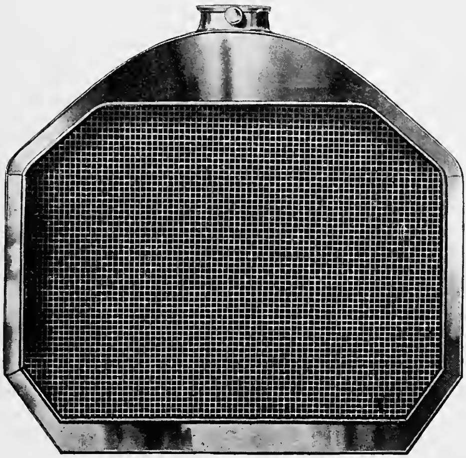

Fig. 2.

near the boiling point of water and that this water will not leave the cylinder until it does get hot. By this system the water level must always be above the water inlet on the radiator to produce the syphon effect. The drop in temperature of the water in the radiator by this system is about 16 degrees F., so that it will be understood we do not mean that the returning water is cold, but that it has been cooled because heat has been given up. At 208 degrees F., 1 cubic foot

of water weighs 59.87 pounds, and at 190 degrees F., 60.32 pounds, making a difference in weight of .45 of a pound. It would hardly seem possible that this small difference in weight could produce a flow of from 8 to 20 gallons per minute. The writer believes that the circulation is aided most by the formation of steam at the surface of the cylinders, which is afterward condensed in its passage upward through the water.

An overflow pipe is provided on each radiator so that there

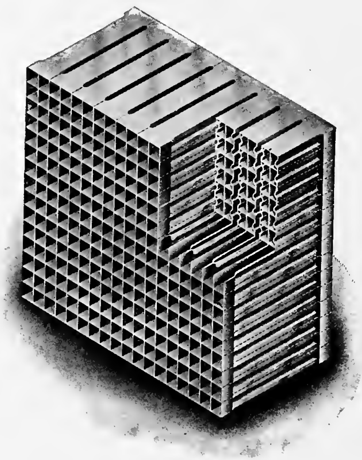

Fig. 3.

will be only atmosphere pressure inside the radiator.

From the foregoing description, operation and principles of a radiator, it will be readily seen that theoretically the case or cells of the radiator, is the radiator proper, and the other parts are merely the carrying agents of the water. For this reason the walls of the water tubes of the case must be very thin and properly spaced. These tubes must also be such that the water will be caused to impinge on the walls of the tube and in so doing, transfer the heat to the walls. By re-

ferring to Fig. 3, the reader can readily see how these points are incorporated in the case.

Without a doubt a leaky radiator can cause a motorist more worry than any other defect of the automobile. For this reason a radiator must be well built and all seams strong enough to take road shocks and not open up. It is certainly aggravating to have to fill the radiator about every ten miles.

A radiator must be light for several reasons. 1st, all material used in its construction is expensive; 2d, the case or cells must be as thin as possible so that the heat will be carried rapidly through the walls of the cells. The time element of the transfer of heat through a plate varies directly as the thickness of the plate; 3d, the object of a light radiator from

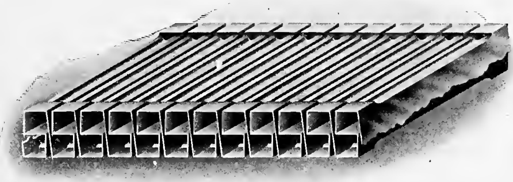

Fig. 4.

an automobile manufacturer's point of view is to have as little weight as possible on the tires. Light weight in an automobile means long life of tires.

As has been said before, the great reason, from a manufacturer's standpoint, in having a light radiator is its reduction in cost. The radiator must also be designed so that as small an amount of labor as possible should be expended in building it.

There should be as little skilled labor required as possible for the reason that skilled labor is becoming scarce in this country; specially instructed labor taking its place. As much automatic machinery as possible should be used, so that parts will be interchangeable.

Clogging up of the tubes in a radiator has been quite an

annoyance in the past. Radiator manufacturers endeavored to make the width of the tubes as small as practical, say 1-32 inch and use as many of them as possible. From experiments it was found that this kind of a radiator worked alright until limestone, or alkali water had been used for about six months, when the tubes clogged up from the incrustations of limestone or alkali. To overcome this, the tubes have been made ⅛ inch wide so that the solid matter will fall to the bottom box.

The wind resistance has two bad effects on the performance of a motor car: 1st, it takes more power to drive a car at a given speed and, 2d, the more resistance a radiator gives to the wind the less the cooling efficiency. By referring to Figs. 5 and 6, it will be seen that the center to center distances of the

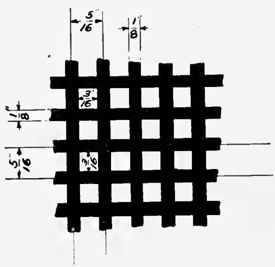

Fig. 5.

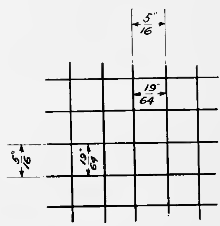

Fig. 6.

squares are the same in both cases, but the air space of the case in Fig. 5 is 3-16×3-16=.0352 square inch. The air space in Fig. 6, is 19-64×19-64=.0882 square inch. From the foregoing it can be easily seen that the sharper the edges of the cells the less the wind resistance, and more air will be forced through the radiator.

Automobiles are now being used in all parts of the world, civilized and uncivilized. A radiator should be so easy to repair that any person with ordinary intelligence could do the repairing. It is often impossible to remove a radiator to repair it because many times the accident occurs miles from a city or even from home. By glancing at Fig. 3, it can be seen that if a cell or number of cells should be injured or

spring a leak, they can be stopped up in the front and back, thus preventing loss of water from the radiator.

Probably 95 per cent of automobiles now made use what is termed the "cellular" radiator. These cells are mostly square and the appearance of the radiator depends much upon the way these cells line up with each other. In this respect great pains are taken to make the cells in the case as symmetrical as possible.

The construction of the radiator will be taken up under the following headings:

1—The case.
2—The sheet metal parts.
3—The assembling and testing.
4—The finishing.

The Case: The case is made up of a number of such units as shown in Fig. 4. These units are formed on an automatic machine from a flat ribbon of brass. The automatic machine does its own feeding, forming the units in one continuous strip, the operator cutting the units to proper length as it comes from the machine, without stopping the machine. A detailed description of these machines is beyond the scope of this article.

Two years of experimenting and a large amount of money was used to perfect these machines and have them do what human hands could not do. There is now a battery of 30 of these machines installed, capable of producing 180,000 radiators per year, working 10 hours per day. It must be borne in mind that these machines handle material .005 inch in thickness, without waste, because this thin material is expensive.

From these machines the units go to the case assemblers who assemble the units in a steel frame, line up the squares both ways, and dip the assembled case in a bath of molten solder. As soon as the case thus dipped cools, the steel frame is removed and the core is now ready for the assembly. At first thought one would suppose that the cells and the water spaces would fill up with solder, but the molten solder is as liquid as water and will only stay between two pieces of metal which are close together say 1-64-inch apart.

The Sheet Metal Parts: By referring to Fig. 1, it can be seen that the sheet metal parts consist of the shell, the top

water box, the bottom water box and the filler cap. The shell is stamped out of one piece of metal. On a radiator shell eleven distinct press operations are performed.

In a similar manner the water boxes are made. The particular operations and methods of producing these parts being out of place to mention in this article. The art of drawing metal is highly specialized and a life study of its own. Blanking and drawing dies are quite expensive and outside of quantity production their cost is prohibitive.

Assembling and Testing: At the assemblers all of the parts for the radiator come together for the first time. They solder the water boxes to the case, plug up the water inlet and water outlet castings and test out the radiator for leaks. Air to a pressure of 15 lbs. is forced inside the radiator, the radiator then being immersed in water. If there are any leaks the tinner or assembler notices them by the air bubbles, which he repairs with a soldering copper. After testing, the assembler places the shell on the radiator and solders the filler cap and it is then ready for finishing.

Finishing: The case is first painted by spraying with paint by compressed air. The compressed air forces the paint in a spray into the cells making a very uniform job. The radiator is then sent to the enamel department where two coats of enamel is baked on the shell. This enamel is likewise sprayed on the shell, thus insuring a very uniform coating. The enamel is baked between each coat. The radiator again goes to the radiator department where it is again tested for leaks. From here it is shipped to the customers. There is a certain routine followed in the manufacturing of radiators and there is an uninterrupted flow of radiators from one operation to another, making an uninterrupted flow of the finished product to the shipping platform. A completed radiator every two minutes is an average. By making a large quantity, a workman does but one thing and the plant is laid out so that the general trend of the radiators from the raw stock to the finished product is toward the shipping platform. It is the case of the man for the job, and the job for the man and the old saying, that "Practice makes perfect."

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Perhaps one of the most fascinating of the lesser important developments of science is that of color photography. To the average user of the camera the idea of color photography is rather vague. One recognizes it as an ideal, beautiful in theory, but only to be realized by the favored few who have both money and leisure in abundance. Whatever its status may have been in the past, it is certainly true that at the present time it is easily within the reach of any one of moderate means and average intelligence if he is willing to exercise a reasonable amount of care and patience.

Up to the present time efforts have been largely confined to the production of transparencies and lantern slides, al-

though strong claims are made for results on photographic paper. As to expense, the writer's experience in lantern slide work has been that the cost per slides is less than half the market price of the ordinary hand colored article, while the results are so infinitely superior that one loses all taste for the finest results of the most skilled colorist.

Of the various methods of color photography in use at the present day, two, the Lumiere and Paget processes are perhaps the most promising, and the writer believes that the former is productive of the truest results, although it has some drawbacks, such as the density of the transparencies and the impossibility of easily making satisfactory duplicates. The latter process, on the other hand, is productive of very brilliant results, and from a single negative any number of slides can be produced. It is unnecessary to go into details as to manipulation, suffice to say that no difficult processes are involved and full directions are given with each package of plates purchased.

To prove the faithfulness of the reproduction, the writer has made lantern slides of objects of art, combining the most delicate and intricate blending of colors and tones, and thrown the production on a screen to natural size, illuminating the original object with the same light and studied the two carefully without being able to detect the slightest difference in any respect.

In landscape work the most marvellous results are attainable. Such a slide projected on the screen shows a perspective or a stereoscopic effect that cannot be obtained in any other way except by the use of complicated and cumbersome auxiliary apparatus. This is due largely to the correct shading of the color tones as the distance from the observer increases. The shadows and the haze of the distances are reproduced in their correct colors and gradations. One sees in many of these pictures things that the average person does not see in the objects themselves—things that the artist depicts on his canvas and the layman claims are figments of his imagination. I refer especially to the finest gradations of color—to the purples of the shadows and an indescribable quality of the haze that gives the charm to distant objects.

The reason we do not see this in nature is that we see in masses and very few of us ever stop to study detail either as to color or form until something of this kind impresses these things on us. This is also true in music. It is only by the greatest effort that the untrained ear can separate out single instruments from an orchestra. We see in masses, just as we hear in masses, and one of the finest functions of photography and especially color photography is that which enables us to study at their true worth the component parts of a beautiful piece of scenery or object of art.

Who can conceive of a more fascinating idea than the possibility of being able, at a small expense, in one's own home, and when one is in the proper mood, by the means of a simple projecting lantern, to place on his walls a series of the masterpieces of painting, things many of us may never hope to see in the original, reproduced more perfectly than even the original master might have achieved. Yet such is easily possible at the present time by the aid of color photography. No doubt we may each have this privilege when the process becomes commercially exploited. Or what can be more interesting than the possibility of taking a trip through the natural wonders of our country, omitting all the fatigues of travel, seated in our easy chair in our own homes and being able to see all that we would see were we to cover thousands of miles of territory and see them under the most ideal of atmospheric conditions. This we may do also by the aid of color photography. These are but two of its countless possibilities. The charm and fascination of photography are certainly increased a hundred fold by the opening up of this new field.

—*John E. Snow.*

It is coming to be more and more a function of our governments to undertake projects promoting the public welfare that cannot be left satisfactorily to individuals but require the co-operation of the entire community for their execution in a practical manner. Such projects are chiefly of an engineering nature. While familiar to all of us as proper objects of governmental activity, the importance of entrusting their

design and supervision to engineers, and not to the ordinary political government agents, is not generally appreciated. Likewise, the opportunities for engineers to interest themselves in government work are frequently ignored.

The variety and number of engineering and closely allied problems in which the public is concerned is almost amazing. Let us enumerate some that come up before municipal governments. Among the most common of these are water supply and purification, drainage, sewage disposal, street paving, lighting and cleaning, garbage, ashes and refuse disposal, bridges, viaducts and tunnels, harbor improvements, parks, erection of public buildings, inspection of all buildings, of boilers and electrical installations, smoke abatement, fire protection, regulation of local transportation and other utilities, etc. Besides, there are coming up broader problems, such as systematic city planning and improved housing, that require the attention of engineers, architects and landscape specialists. Some of these municipal activities may at first sight not seem of a character to interest engineers; nevertheless, it was an engineer that developed a highly perfected street-cleaning system for one of our largest cities and a number of chemical engineers have developed satisfactory systems of garbage reduction.

While a large city needs the work of engineers more than any other of our governments, even the rural community can employ his services to good advantage. One of the reasons why cities are growing and country districts becoming depopulated is the isolation and lack of social and educational opportunities of the latter. By the construction of mutual telephone lines and good roads the farmer is brought into close touch with his neighbors and with the nearest towns. In Germany extensive electrical systems, known as "oberlandcentral," are furnishing farmers with cheap and convenient power and light; it is only a question of a few years when similar undertakings will be developed in this country on an equal or even larger scale, although at first probably by private corporations. Irrigation projects are of prime importance to the farmers in arid districts. In others, drainage systems are sadly needed.

State governments are interesting themselves in the building of good roads so as to develop a comprehensive network of important highways passable at all seasons of the year between at least the principal towns. In other places canal construction is again being taken up and in connection therewith hydroelectric development is proposed. In some states engineering studies are being made, looking to the control of rivers so as to prevent disastrous floods, such as those of the spring of 1913. A new and important branch of state government activity is the regulation of public utilities. Over one-half of our states now have commissions that have jurisdiction over railroads, interurban and street railways, telephone and telegraph systems, electric light and power companies, gas and district heating companies, and other public utilties within the state. The regulation of such utilities is very largely of an engineering character, in fact in those states, like Wisconsin, New York and Massachusetts, where it has been most highly developed, there is employed a large engineering corps that among other duties makes valuations and supervises service. And yet among the commissioners themselves there are but few engineers.

Of the opportunities for engineering work for our national government it is not necessary to speak at length. Much of the engineering work, at least on navigable rivers, government canals and harbors, is handled creditably by engineers trained primarily for military service. In the reclamation service, mines and standards bureaus, the construction and supervision of federal buildings, and in several other branches of government work there is need for a considerable number of engineers.

Despite these varied governmental activities in which the engineer is imperatively needed, as a rule the engineer does not now receive the recognition in public affairs that should be accorded him. Although there are many competent engineers in public service, their number and influence is not what it should be. The general policy on important public questions of engineering nature is frequently determined by assemblies or boards in which the engineer is conspicuous by his absence. We therefore find, as a result of this practice,

that many projects are undertaken without proper consideration or are carried out improperly and inefficiently; other projects that would greatly promote public safety, convenience or welfare are delayed indefinitely.

These conditions need not turn us to pessimism, however. Reform is all that is needed. Analysis of the situation discloses that the apathy of the public in engineering questions is due to pardonable ignorance and to lack of sufficient engineer leaders who command the respect of the community. Fortunately it lies largely in the power of the engineer himself to remedy these conditions. If he looks down on public service as beneath his dignity and if he is too engrossed in his work to even register and vote at elections, he cannot criticise inefficient public engineering work, nor need he fret at the absence of engineers on commissions entrusted with the execution of important projects. In these days, when even women are eagerly seeking suffrage as a means of reform, it is evident that the ballot has a larger potential power than in those days, now happily almost gone by, when the political boss was supreme at elections.

Many people are seeking still further governmental activities of engineering character through government ownership and operation of public utilities. It is evident that the prevailing inefficiency of very many departments of government work make such a policy highly inadvisable at the present time. But if it ever is to be put into general practice, it will be when the engineer rises to not only his opportunities but his duties in government work. Meanwhile it behooves him to keep closely informed on engineering work of a public nature, and, if he has the welfare of the community at heart, to attempt to guide it in an intelligent and efficient manner.

—*Bernhard.*

A good engineer must be of inflexible integrity, sober, truthful, accurate, resolute, discreet, of cool and sound judgment; must have command of his temper; must have courage to resist and repel attempts at intimidation, a firmness that is proof against solicitation, flattery, or improper bias of any

kind; must take an interest in his work; must be energetic, quick to decide, prompt to act; must be fair and impartial as a judge on the bench; must have experience in his work and dealing with men, which implies some maturity of years; must have business habits and knowledge of accounts.

Men who combine these qualities are not to be picked up every day; still they can be found. But they are greatly in demand; and, when found, they are worth their price—rather, they are beyond price, and their value cannot be estimated by dollars.—*Chief Engineer Sterling's Report to the Mississippi Levee Commissioners.*

ARMOUR INSTITUTE OF TECHNOLOGY BRANCH OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

Since the last number of THE ARMOUR ENGINEER we have had but one regular meeting, this being held in the Physics lecture room the evening of March 4. However, besides the one regular meeting since the beginning of the second semester we have had our annual banquet at the Boston Oyster House.

The banquet took place Friday evening, January 23. Plates for forty-one were served, including many members of the faculty and alumni. On the toast list were two of the members of the faculty, Professors G. F. Gebhart and C. E. Paul. Both professors had many things to tell us, concerning the value of membership in Engineering Societies and other points of interest to the students. President H. E. Erickson acted as toastmaster. After the dinner some of the boys favored us with piano selections, popular airs, which we all sang.

Mr. Oscar Goetz, '14, and Mr. Lyman Close, '15, addressed the students at the fifth meeting (March 4) of the society. The subjects were "Kerosene Carburators and Carburation," and "Vehicle Springs," respectively. Both talks were very instructive and the speakers deserve great credit. Mr. Goetz talked very fluently on the various kerosene carburators on the market, laying particular stress upon the Harroun carburator. Mr. Close dealt with the history of springs, commencing with the wooden springs used in the early ages and showing the improvements made up to date. He brought his subject to a climax by showing the modern automobile spring, during the processes of manufacture.

—*Albert N. Koch.*

ARMOUR CHEMICAL ENGINEERING SOCIETY.

The first meeting of the second semester was held February 10 in Chapin Hall, and we regret to say that the speakers had

to face the smallest audience of the whole year. Dr. Tibbals gave a splendid talk on "Tellurides," a subject on which he did a great deal of research work and for which he received his Ph. D. degree from the University of Wisconsin. He furthermore favored the members with pamphlets containing his complete work. Mr. Gothwaite, '15, read a very good paper on the "Production of Asbestos." This was not merely copied from various literature on the subject but was material which he had personally collected from his visits to various plants in Canada.

On February 23, Mr. Wilsnack, late acquisition to the Chemical Department, was first introduced to the society and gave some valuable points in his talk "Tips to Seniors." The Seniors realize, as the time for Commencement grows nearer that they can greatly profit by hearing about the experiences and problems of the alumnae. Mr. Sieck, '15, gave a talk on "Cocoanut Oil," and Mr. Finklestein, '14, gave a discussion on "The Skeptical Chymist," by Robert Boyle.

The meeting held March 9 was featured by Mr. E. V. Turley, '12, with his talk on "Colloidal Nickel in the Hydrogenation of Oils." Mr. Turley worked on this subject for his thesis and since that time has put his information to practical use. The talk was very practical and instructive, giving us facts which could not be obtained from any other source. Several of the alumni were present and we invite them to come again and to bring others with them.

—*F. W. Hook.*

CIVIL ENGINEERING SOCIETY.

Since the last issue of the Engineer the Civil Society has enjoyed a number of very interesting and instructive discussions, to say little of a visit by its members to the cement show at the Coliseum and a snappy smoker, which followed a short business session called for the purpose of electing officers for the ensuing year. This particular meeting was the first one since the last issue of the Engineer and was

held in the Y. M. C. A. rooms on Tuesday, February 3. With the entire membership and a goodly number of alumni out. The meeting was called to order by President Smith. The names of the candidates from the different political parties for the various offices were placed on the board and the voting was done by ballot with the following result

President—George Sproesser.
Vice-President—George Trinkaus.
Recording Secretary—Wm. V. Lindblom.
Corresponding Secretary—Theodore J. Kiene.
Treasurer—Leonard D. Hook.
Student member, board of control—F. N. Compton.
Faculty member, board of control—M. B. Wells.

The business was completed and the more material enjoyment was indulged in, namely, "eats," which our able social chairman, Walter H. Hallstein, had prepared for us. The activities and the spirit with which they were entered into were conclusive proof that the vituals had struck the right spot of every one, for no less than ten aspirants took part in the slug-fests that followed.

The next regular meeting was slated for February 17, and on this occasion our president again demonstrated his qualifications by doing, what is apparently impossible for the deans to do, that is presented each member of the society with a complimentary ticket to the cement show. The result was that the entire body went down to see the exhibit, spending a very profitable evening.

On March 3 the society again met, this time to listen to Mr. Lynn White, chief engineer for South Park Commission, who presented a paper on "The advantages in civil service work to the college graduate." It is idle to say that this paper, containing the boiled down facts and carefully drawn conclusions derived from many years of experience and study, proved very interesting and instructive.

We are glad to say that many sophomores took advantage of the occasion and we trust they will continue to do so at future meetings.

—*E. G. Zack.*

FIRE PROTECTION ENGINEERING SOCIETY.

The first meeting of the students of the Fire Protection Engineering Department was held Tuesday, November 11. The meeting was called to order by Walter C. Gielow, who was elected temporary chairman, and E. M. Kratz was elected as temporary secretary. The outlook and need of a Fire Protection Engineering Society was then discussed, which resulted in a great deal of enthusiasm being brought out by those present. A short business session was then held in which the following officers were elected:—

President—W. C. Gielow.
Vice-President—W. H. Rietz.
Secretary—E. M. Kratz.
Treasurer—S. W. Anderson.

Meetings were held on November 25, and December 3 for the purpose of revising and discussing the constitution. On January 27th, an address was given by Professor Fitzhugh Taylor on the subject of automatic sprinkler systems and fire alarms. This lecture was largely attended by the students of other departments who realized the practical application of the subject. Professor Taylor outlined very clearly the operation and installation of sprinkler systems and their importance in the insurance field. The merits and demerits of the present systems were thoroughly discussed and illustrated with the aid of lantern slides.

On the 24th of February, a second lecture was given by Mr. W. H. Fredericks, on the subject of the field work of the National Fire Prevention Committee of the National Board of Fire Underwriters. Mr. Fredericks is connected with the Underwriters Laboratories of Chicago. This lecture was of great value to the students because of its practical value.

—*E. M. Kratz.*

Alumni Department

THE ALUMNI AND THE ARMOUR ENGINEER.

At the time The Armour Engineer was started, we had already two college publications, the "Fulcrum," issued monthly, and the "Integral," an annual. These two journals were devoted to the purely local interests of the Armour Institute of Technology, and the first was intended for circulation among the students, largely as a newsy medium to keep alive the college spirit.

However, we were more ambitious than this, and it was thought that, among the alumni, there should be many engineers whose opinions on subjects of engineering importance would be worth while, and whose loyalty might be sufficiently great to keep up a publication of a somewhat different type, namely, a purely technical one, devoted only to science and engineering. It was intended that this journal, The Armour Engineer, should be representative of the progress in engineering made by the alumni of the Armour Institute of Technology, and that it should be a high-grade technical journal, not at all devoted to student activities, or to the activities of the alumni, except in a professional way.

The Armour Engineer has now a fairly large circulation, among engineers and others whose opinions are of importance; articles appearing in it have been copied in many quarters, some in foreign countries, and we have high hopes of building up here a *technical* periodical which shall reflect considerable credit upon the Armour Institute of Technology and its alumni by the engineering excellence of its articles. This end can be attained if the alumni body will co-operate by contributing papers of value in the field of engineering; it can *not* be attained if the alumni body is indifferent, or if it expects in this journal merely a rather silly chronicle of the goings

and comings of its members. News items of purely local interest are not able to win for us more than purely local recognition, and are powerless to build up a favorable name and reputation for the Armour Institute of Technology.

Many members of the alumni are engaged in engineering work of a high type; papers by them are valuable contributions, and we wish to insure for these papers a setting worthy of them, which means a periodical of the highest grade throughout. It is our purpose to maintain this high standard, and we invite you to help us.

—*H. W. Nichols.*

It has been said somewhere that "it pays to advertise." We are assured that this is a fact from the very gratifying returns that we are constantly receiving. We feel that our efforts are being repaid.

It will not be very long before we will have almost all of the Alumni enrolled upon our books as members in good standing.

We have not reached them all as yet because of faulty addresses. This we are trying hard to remedy and a system for handling this most perplexing question is now being studied out and we hope will be inaugurated this year.

There are about 1,000 men that are either graduates of the school or eligible for associate membership in the Association. An engineer from the very nature of his business is somewhat migratory in his habits until such a time as he has gained sufficient experience to warrant him to settle down. Unless he informs us of his whereabouts we finally lose him. This we propose to stop. We expect to make the Alumni Department of this publication so interesting concerning matters of real interest to him that he will of his own free will and accord "look us up," because he will want the news from home that it necessarily brings. This you see is our chance to seek him out.

After all, dear brothers, we are one large family and we

should be proud to be members of it. The consideration is small and by its payment the good-will of the individual is signified. "The reward for having done a good deed," says Elbert Hubbard, "is to have done it." Your officers are your servants, and they, I am sure, have no motive but to do their utmost in your behalf. The recognition of their efforts is the only reward they receive. They thank you for it most heartily.

SPRING REUNION.

Now is the time to write to your President and put in your suggestion or requisition for the form of entertainment that you wish for the Spring Reunion.

This much is now established. It will be held at the Institute, on May 23, 1914. SAVE THE DATE. It's Saturday, and the weather will be unusually good.

We can also announce that an entertainment of UNUSUAL interest has been secured, the details of which will be given in the next issue.

CONSTITUTION AND BY-LAWS.

For the benefit of the members, the constitution of the Alumni Association is printed herewith. Please read it over because we expect to offer some amendments to it at the Spring meeting. The amendments will particularly apply to the "Booster Committee," the permanency of which it is desired to establish.

ARTICLE I

NAME

The name of this Association shall be "The Alumni Association of Armour Institute of Technology."

ARTICLE II

OBJECT

This Association shall have for its object the promotion of fellowship and good-will among its members; and to keep alive their interest in affairs of Armour Institute of Technology.

ARTICLE III

OFFICERS

SECTION 1. The officers of the Association shall be a President, a Vice-President, Corresponding Secretary, Recording Secretary, Treasurer and Master of Ceremonies, and shall hold office for one year, or until their successors are chosen.

SECTION 2. The President shall preside at the business meetings of the Association and the Board of Managers. The President shall, with the Recording Secretary or the Treasurer, sign all written contracts and obligations of the Association, and shall perform such other duties as the Board of Managers or the Association may assign him.

SECTION 3. The Vice-President in the absence or disability of the President, shall perform all duties ordinarily incumbent upon the President.

SECTION 4. The Corresponding Secretary shall, as far as possible, keep a correct roster of the membership of the association, with their addresses and occupations. He shall assist the members in keeping in communication with each other and shall issue all notices required.

SECTION 5. The Recording Secretary shall keep the minutes of the meetings of the Association and of the Board of Managers. He shall keep the records and seal of the Association. He shall notify candidates for office of their election, shall provide applicants for membership with application blanks, register the names of the members and furnish them to the Treasurer.

SECTION 6. The Treasurer shall collect all fees and dues, and shall keep all of the accounts of the Association and report thereon whenever requested by the Board of Managers. His accounts shall be audited annually by the Finance Committee. He shall prepare an annual statement and submit it to the Finance Committee, who shall certify as to its correctness previous to the annual meeting.

SECTION 7. The Master of Ceremonies shall have charge of all social functions of the Association. He shall with the consent of the Board of Managers appoint the place and time of all reunions, and all gatherings not of a business nature. He shall appoint speakers and provide entertainment for such gatherings. He may with the consent of the Board of Managers levy an assessment upon all members of the Association present, sufficient to cover the expense of the entertainment.

SECTION 8. Only active members shall hold office.

ARTICLE IV

BOARD OF MANAGERS

SECTION 1. The Board of Managers shall have general charge of the affairs, funds and property of the Association. They shall have full power and it shall be their duty to carry out the purposes of the Association according to its charter, constitution and by-laws. The Board shall consist of the six officers of the Association and nine other active members who shall be elected at the annual election for the year 1910 in the following manner: Exclusive of the officers, three Managers shall be elected for the term of three years, three Managers shall be elected for the term of two years, and three Managers shall be elected for the term of one year. The term of office of the Managers, exclusive of officers, elected after the year 1910 shall be three years and at each annual election thereafter all of the officers of the Association and active members to replace the three outgoing Managers shall be elected by ballot. A plurality of votes cast shall elect.

SECTION 2. The Board of Managers shall meet at least three weeks before each regular meeting of the Association. A special meeting may be called at any time by the order of the President. A majority of its members shall constitute a quorum of the Board.

ARTICLE V

MEETINGS AND ELECTIONS

SECTION 1. The annual meeting with the annual election of the Association shall be held in Chicago, State of Illinois, within ten days prior to the graduating exercises of the Institute. There shall be a reunion in Chicago during the week preceding Christmas.

SECTION 2. Officers and other members of the Board of Managers shall hold office during the terms for which they are elected, or until their successors are chosen.

SECTION 3. The Boards of Managers shall have power to elect officers and other managers to fill vacancies until the next annual election.

SECTION 4. A special meeting of the Association may be called by the Board of Managers or by twenty active members in good standing. A notice of such meeting shall be mailed to each member of the Association, stating the objects for which it is called, and only objects mentioned in such notice or matters clearly germane thereto shall be considered at such special meeting.

SECTION 5. Forty active members shall constitute a quorum at any meeting of the Association.

ARTICLE VI

QUALIFICATIONS OF MEMBERS

SECTION 1. There shall be three classes of membership, active, associate, and honorary.

SECTION 2. Graduates and men who have received advanced degrees from Armour Institute of Technology shall be eligible to active membership.

SECTION 3. All former technical college students who have completed two years' work and all members of the faculty of Armour Institute of Technology, shall be eligible to associate membership. Associate members shall have all of the privileges of the Association except holding office.

SECTION 4. Persons eligible to active and associate membership shall be admitted upon the signing of application blanks prescribed by the Board of Managers.

SECTION 5. Honorary membership may be conferred upon such persons as the association shall elect, by a majority vote of those present at the regular meeting after recommendation by the Board of Managers.

ARTICLE VII

RESIGNATION, EXPULSION, AND REINSTATEMENT

SECTION 1. Resignation of membership shall be made to the Board of Managers in writing.

SECTION 2. Any member may be expelled for cause by a vote of not less than nine members of the Board of Managers; provided that written notice of the charges preferred against him shall have been given him at least two weeks prior to such action, and he shall have the privilege of acting in his own defense.

SECTION 3. Any member in arrears for two years' dues shall be dropped from membership, but he shall be reinstated upon the payment of these arrearages.

ARTICLE VIII

FEES AND DUES

SECTION 1. Every member admitted to active or associate membership shall pay an initiation fee of one dollar, payable in advance.

SECTION 2. Dues shall be one dollar per year, payable in advance.

SECTION 3. Any member in good standing may become a life member on payment of twenty dollars.

That all moneys received from the payment of Life Membership shall serve as a trust fund, placed at the disposal of the Scholarship Committee, who shall repay to the General Fund of the Alumni Association all interests received from the use of such trust funds.

ARTICLE IX

APPOINTMENT OF STANDING COMMITTEES

SECTION 1. The Board of Mangers shall appoint from its own members a Finance Committee of three members, and a Scholarship Fund Committee of three members; these committees to be standing committees for the current official year, subject, however, at all times to the direction and control of the board of managers. The Chairman of each of such Committees shall be designated by the Board of Managers.

SECTION 2. The Finance Committee shall audit the accounts of the Treasurer annually and report to the Board of Managers, and shall audit and certify all bills of the Association.

SECTION 3. The Scholarship Fund Committee shall solicit contributions for a fund to be known as the Scholarship Fund, and they shall have full charge of its distribution. They shall keep an accurate record of all moneys received and loaned and shall hand to the Treasurer for safe keeping all such funds. The disbursements from this fund shall be made by the Treasurer upon order of the Committee. The Committee shall confer with representatives of the faculty with regard to each loan and shall give due consideration to any recommendations made by the faculty. The Committee shall make an annual report to the Board of Managers.

ARTICLE X

COMMITTEE OF NOMINATIONS

SECTION 1. It shall be the duty of the Board of Managers to appoint before the first day of May each year a Committee on Nominations of five members. No member of the Board of Managers shall be appointed a member of such Committee and no two members shall be of the same class. This committee shall prepare and hand to the Corresponding Secretary in time to place on the notification of the annual meeting a list of nominations for the various offices to be filled. Nomination may be made by any active member present at the time of the election. Voting shall be by ballot. The presiding officer shall make appropriate provision for the conduct of the election and shall appoint three members of the Association as tellers, who shall count the votes promptly and report to the Recording Secretary.

ARTICLE XI

LOCAL BRANCH ORGANIZATION

SECTION 1. Upon the receipt of a petition, signed by at least ten members in good standing, who live in the same general location outside of Chicago the Board of Managers may sanction a local Branch Organization. The Branch Organization shall be governed by its own rules, but shall pay a yearly fee of fifty cents to the parent organization for each member of the branch organization.

ARTICLE XII

AMENDMENTS

SECTION 1. The Constitution and By-Laws may be amended at any annual or special meeting of the Association by a vote of two-thirds of the members present. Notices of proposed amendments shall be furnished to the Recording Secretary and mailed to members at least one week before the meeting at which it is proposed to consider them.

ARTICLE XIII

ORDER OF BUSINESS

SECTION 1. The Order of Business shall be:

1. Reading of minutes.
2. Report of committees.
3. Unfinished business.
4. New business.
5. Election of officers.

ALUMNI NOTES.

H. S. Ellington ('08) is in Detroit, Mich., superintending the erection of a large new brew house for the Stroh Brewing Company. He reports that his "connection" with the brewery is unusually favorable and satisfactory.

Eustace Vynne ('10) is with G. W. Wood Company, cloth manufacturers, Chicago. It must be admitted that an engineering education qualifies a man to follow any business there is.

Charles W. Hills is, as his name implies, the junior member of the firm of Charles W. Hills & Son, patent-right attorneys, with offices in the Monadnock building. "These younsters" will grow up and this fact finally becomes recognized.

W. R. Tobias ('11) is in Los Angeles, Cal., doing business for himself.

C. C. Bailey ('10) is with the General Electric Company, in Schnectady, N. Y. We do not know exactly what he does but trust that when he reads this he will let us hear from him.

P. H. Hockenberger ('15) is paddling his own canoe in Oakland, Cal. Business must be good, because we are advised that he has lost his heart. We will not mention the young lady's name until we are sure that the matter is "cinched."

Bruce Young is superintendent of the Crofts & Reed Co., Chicago. You can't hold a good man down.

Leroy Kiley ('12) not being satisfied with an ordinary engineering education is now studying law and is now with Charles W. Hills & Son, patent-right attorneys. You never can tell from the sign of a frog how far he can leap.

R. S. Torrance ('06) is the "Co." in S. R. Fralick & Co., Chicago. Ralph certainly looks well and prosperous.

R. W. Hall is doing fine with the Holtzer-Cabot Electric Co., of Chicago. We knew he would.

A. W. Boylston ('06) is with Mehring & Hanson, steamfitters, Chicago. We are told that he is doing very well.

F. A. Coy ('04) has been in Chicago about two years since he was driven out of Mexico by the war. He says that "War is Hell," and we agree with him.

W. H. Dean ('05) is in the Construction Division of the

Bureau of Engineering, City Hall. He is now engaged upon the work of building a Municipal Iron and Brass Foundry.

Edwin H. Ellet ('07) is one of the most enthusiastic members of Company A, Engineering corps. He has just finished an examination which will place him on an eligible list of the officers of Volunteer Companies. "Ted" will be a volunteer officer in time of war. We are proud of him.

J. B. Swift ('01) is another enthusiastic in Company A, Engineers.

Charlie Lawrence is still running his orchestra. Charlie is some musician. You have our word for it.

G. W. Niestaft ('03) is still with the Vierling Steel Works. We are sure that this company would be up against it if it were not for George. He also reports that he is the proud father of a ten months old daughter.

E. J. Wickersham ('04) is with A. L. Drum, Consulting Engineer. Wick says he is very busy, and no doubt he is. We have requested him to give an account of himself, and he no doubt will for "our next."

LOST, STRAYED OR STOLEN.

The location of the following named graduates has been changed recently and mail sent to addresses at hand has been returned undelivered. Information regarding their whereabouts will be most welcome. Kindly send it to F. G. Heuchling, 1310 Glenlake Avenue, Chicago.

Howard J. Ash, '05
Marion W. Briggs, '02.
Harold K. Copenhaver, '07.
Alfred A. Ebert, '09.
C. A. Eckland, '09.
George C. Erickson, '12.
James H. Fletcher, '11.
Robert B. Harper, '05.
Ralph Holmtoe, '08.
Joseph B. Lindquist, '13.
William C. Mann, '13.
Robert C. Martin, '00.
Victor S. Person, '02.
Olin L. Richards, '10.
Fred Schmidt, '12.
Dan. M. Stump, '13.
M. I. Tong, '13.
Frederick W. Twitchell, '99.
Frank J. Neson, '09.
Louis T. Zeisler, '10.

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ELECTRICAL INSPECTION.

BY VICTOR H. TOUSLEY.*

Electrical inspection began in the years when electrical apparatus first became developed to a point where its commercial application became possible. As the field of electrical industries became broadened out, and various new and developed types of apparatus came into use, electrical inspections became of greater importance.

It has always been recognized that the use of the various classes of electrical apparatus has been attended with certain dangers to life and property from fires and shocks, and the necessity for some supervision was early evident to, more particularly, the life and fire insurance companies. Many municipalities and other governing bodies recognizing the growing importance of the necessity of some control of electrical installations passed various ordinances and laws regulating electrical construction.

Some of the earliest ordinances were passed in 1883. The following ordinances were passed by the City of Harrisburg, Penn., on August 8, 1883, and illustrates the status of electrical construction at that time.

An Ordinance

Establishing Rules and Regulations for the Use and Management of Electric Lighting Apparatus in the City of Harrisburg.

SECTION 1. *Be it ordained by the Select and Common Council of the City of Harrisburg,* That all corporations, companies, partnerships and individu-

*Class 1897, Chief Electrical Inspector, City of Chicago.

als, establishing, owning, conducting or operating electric lighting apparatus in the city of Harrisburg, shall observe and comply with the following rules and regulations, viz:

WIRES

Conducting wires over buildings must be seven feet above roofs, and also high enough to avoid ladders of the fire department.

Whenever the electric light wires are in proximity to other wires, dead guard wires must be placed so as to prevent any possibility of contact, in case of accident to the wires or their supports. Conducting wires must be secured to insulating fastenings and covered with an insulation which is water proof on the outside and not easily worn by abrasion. Whenever wires pass through walls, roofs, floors, or partitions; or there is liability to abrasion, or exposure to rats or mice, the insulation must be protected with lead, rubber, stoneware, or some other satisfactory material. Wires entering buildings must be wrapped so that water cannot enter through the tubes.

For inside use, loops of wire must be avoided, and the insulating fastenings arranged to keep the wires free from contact with the building.

Joints in wires to be securely made and wrapped; soldered joints are desirable but not essential. Wires conducting electricity for arc lights must not approach each other, nearer than one foot, and for incandescent lamps, the main wires must not be less than two and a-half inches apart.

Care must be taken that the wires are not placed above each other in such a manner that water could make a cross connection.

A cut out which can be operated by the firemen or police must be placed in the circuit in a well protected and accessible place where property owners or insurance companies desire it.

LAMPS.

For arc lamps, the frames and other exposed parts of the lamps must be insulated from the circuit. Each lamp must be provided with a separate hand switch; and also with an automatic switch which will close the circuit and put the lamp out whenever the carbons do not approach each other, or the resistance of the lamp becomes excessive from any cause. The lamps must be provided with some arrangement or device to prevent the lower carbons from falling out, in case the clamp should not hold them securely.

For inside use, the light must be surrounded by a globe which must rest in a tight stand, so that no particles of melted copper or heated carbon can escape, and when near combustible material, this globe must be protected by a wire netting. Broken or cracked globes must be replaced immediately. Unless a very high globe is used, which closes in as far as possible at the top

it must be covered by some protector reaching to a safe distance above the light.

For incandescent lamps, the conducting wires leading to each building and to each important branch circuit must be provided with an automatic switch or cut-out, or its equivalent, capable of protecting the system from any injury due to an excessive current of electricity.

The small wires leading to each lamp from the main wires must be very thoroughly insulated, and, if separated or broken, no attempt made to join them while the current is in the main wires.

DYNAMO MACHINES.

Dynamo machines must be located in dry places, not exposed to flyings or easily combustible material, and insulated upon wood foundations. They must be provided with devices capable of controlling any changes in the quantity of the current, and, if these governors are not automatic, a competent person must be in attendance near the machine whenever it is in operation.

Each machine must be used with complete wire circuit, and connections of wires with pipes, or the use of ground circuits in any other method, is absolutely prohibited.

The whole system must be kept insulated, and tested every day for ground connections at ample time before lighting, to remedy faults of insulation, if they are discovered.

Preference is given for switches constructed with a lapping connection, so that no electric arc can be formed at the switch when it is changed, otherwise the stands of switches, where powerful currents are used, must be made of stoneware, glass, slate, or some incombustible substance which will withstand the heat of the arc when the switch is changed.

SECTION 2. Any person, firm, company or corporation who shall fail or refuse to observe and comply with any of the rules or regulations established by the first section of this Ordinance; or, shall omit any precaution therein prescribed, or shall violate any of said rules or regulations, shall on conviction thereof before the Mayor or any Alderman of the city be fined not exceeding one hundred dollars. The provisions of this Ordinance to take effect October 1st, 1883.

At the present time practically every city, town and village of any size in the United States and Canada makes some provision for inspecting electrical wires and apparatus. In the smaller towns and villages this may be done by the chief of the fire department, or in some cases by the building in-

spectors. In many instances the local fire underwriters maintain inspection bureaus and inspect all electrical work; in other instances electrical work is inspected by the lighting companies.

A description of the methods employed in the large cities, such as the City of Chicago, will serve to illustrate the objects which it is desired to attain by electrical inspection, and the methods in which such inspections are carried out.

The City Code of Chicago provides for the organization of a Department of Electricity and includes in such organization a bureau designated as the Electrical Inspection Bureau, which handles only the inspection of electrical work. This code provides for the taking out of permits to do electrical work, the obtaining of certificates before current is used, the manner of charging for inspections, and various details regarding the installation of electrical apparatus.

Before any electrical work is done, either inside buildings or upon the streets or alleys, a permit must be obtained. This permit describes in some detail the character of the work, as well as the apparatus to be used, and the time the work is to be done. Upon receipt of application a permit authorizing the applicant to do the work specified is issued. The necessary inspections are then made, and when the work has been completed in accordance with the rules and regulations, a certificate of approval is issued, which must be turned over to the lighting companies, before they can supply current.

The bureau is supported by yearly appropriations made by the City Council from the general fund of the City. A revenue is obtained by charging for each inspection made in accordance with the rates determined by City Ordinance. At the present time there are 67 employes engaged exclusively in the electrical inspection work. This includes 45 inspectors and the other necessary employes to properly carry on the work. The appropriation of the bureau for this year amounts to approximately $124,000, all of this money being expended for the one object of lessening the loss from electrical fires and accidents.

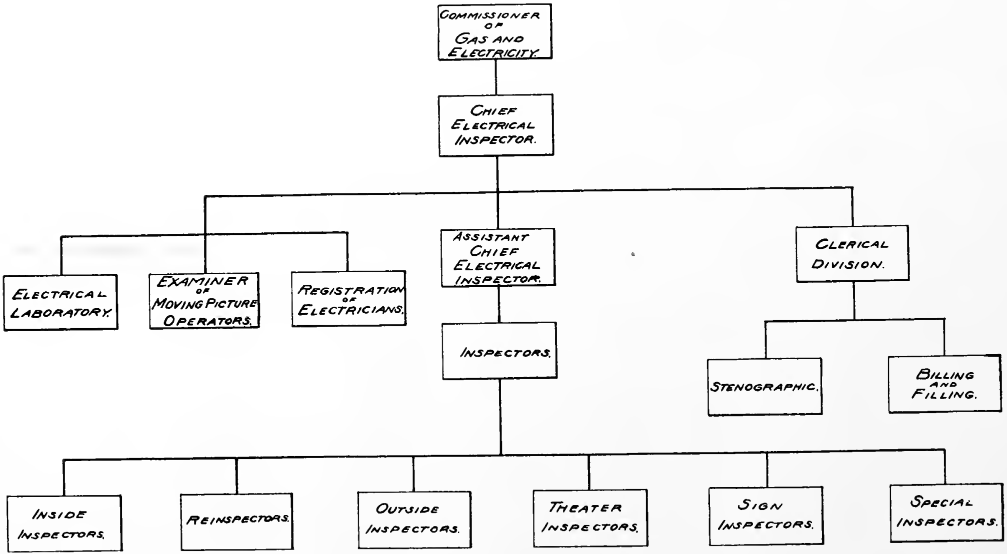
Commissioner of Gas and Electricity.
Chief Electrical Inspector.
Electrical Laboratory.
Examiner of Moving Picture Operators.
Registration of Electricians.
Assistant Chief Electrical Inspector.
Clerical Division.
Inspectors.
Stenographic.
Billing and Filling.
Inside Inspectors.
Reinspectors.
Outside Inspectors.
Theater Inspectors.
Sign Inspectors.
Special Inspectors.

Figure 1

Some idea of the work done in a year may be gained by the following statistics taken from the annual report for 1913:

Revenues, $193,286.

Number of inspections made on inside work, 114,686.

Installations in progress of inspection, December 31, 1913, 14,317.

Permits, outside work, 2,863.

Number of inspections, outside work, 3,122.

The prime object of electrical inspections is to insure safe electrical installations. To accomplish this, it is, of course, necessary to inspect all, or at least the greater part of the electrical work that goes in. After the work has been installed, there is a certain amount of it which will fail and probably result in a fire or fatal accident. In order to draw the proper lessons from these failures, so that necessary precautions may be taken to avoid their recurrence, careful investigations must be made of every fire and of every accident, and the exact cause of such fire or accident ascertained if possible.

Rules for the guidance of persons installing electrical apparatus are absolutely necessary, and these are generally supplied by the municipality or insurance making the inspections. Practically all rules throughout the United States and Canada are based on the National Electrical Code with such modifications as may be necessary due to purely local conditions.

A brief description of the National Electric Code will indicate the thoroughness and consideration given to the formation of new rules, and the revision of old ones. The work of revising the Code is in the hands of the Electrical Committee of the National Fire Proctection Association. This committee includes among its members representatives from all parts of the United States and Canada and from every branch of the electrical industries. Meetings are held every year at which various suggestions for new rules or changes are taken up and considered. The Electrical Committee then reports to an open meeting where any person interested has the right to be heard, and the action taken by this open meeting is final as it affects changes in the code. There is prob-

ably no set of standard specifications in any branch of work more generally recognized as the National Electrical Code.

After the National Electrical Code is revised, certain changes are made in it by various cities to comply with local conditions. In the City of Chicago this work is placed in the hands of a committee representing the municipality, the fire insurance interests, electrical contractors, lighting companies and the organizations of wiremen. This committee makes recommendations to the Commissioner of Gas and Electricity as to changes in the code.

The organization of an inspection bureau is shown by the chart, figure 1, which outlines the organization of the Electrical Inspection Bureau of the Department of Gas and Electricity of the City of Chicago. Most inspection bureaus follow, to a greater or less extent, the system outlined by this chart. It is, of course, necessary to inspect all new work and this is generally done. An efficient inspection organization should include a division for the reinspection of older installations. In a number of cities little or no effort is made to maintain the high standard generally required for the new work, while as a matter of fact, this is just as important, if not more so, than the original inspection.

All outside electrical work, or work installed on streets and alleys should be subject to supervision, both when erected and at regular intervals after its erection. Numerous accidents occur on overhead lines, and these may occur very frequently if the lines are not kept in first class condition. The inspection of underground apparatus, such as conductors, etc., while not of as great importance as the overhead construction, should be properly supervised.

To reduce the number of inferior installations, some supervision of the wiremen or contractors should be obtained, and many municipalities provide for this by licensing wiremen and electrical contractors. This regulation is very essential, and conduces to a better class of construction.

While the rules of the National Electric Code provide a quite thorough standard for materials and construction, still it is impossible for the inspector to determine whether each particular piece of apparatus meets these specifications. The

underwriters' laboratories test all apparatus submitted to them and issue reports to inspection departments covering the results of such tests, and report these results in regularly issued pamphlets. Using the two books in conjunction, the National Electrical Code and the List of Approved Fittings, the inspector and the wireman is given all the instruction necessary to obtain both good work and standard material. However, many inspection departments find that the laboratory as an adjunct to their inspection work is of great importance. This laboratory may be used for the purpose of checking the results of the underwriters' laboratories, or may be used for many classes of apparatus which are constantly encountered during inspection, but which are not regularly manufactured for the market. A laboratory may also be used for the purpose of making investigations of the materials furnished on various installations as well as materials carried by contractors of supply houses. These investigations, if properly carried on, greatly reduce the work of the inspector in the field, and obtain results that it is impossible for the inspector, who is generally quite busy with his detail duties, to accomplish. A laboratory may also be of great service in the investigation of fires and accidents, or making necessary tests of defective material.

Many inspection bureaus also include in their work the examination and licensing of moving picture operators. This is a very important phase of inspection work owing to the fact that a highly inflammable film is used in a building which houses a considerable number of people. The licensing of moving picture operators insures the obtaining of competent men, and this examination backed up by a rigid inspection will greatly tend to cut down the fires from this source.

A very needed supervision which has not yet been obtained as far as the writer knows, is that of the sale of electrical apparatus. At the present time inspection departments have no jurisdiction over such sales, and it is therefore possible for unscrupulous supply men to dispose of defective material with the result that property owners are often put to great expense on account of having to tear out work which has been done with this class of material. A far broader field, how-

ever, is presented in the sale of the various classes of electrical apparatus by department stores and others. It is found in all inspection departments that apparatus which is hazardous from both a life and fire standpoint is sold in unlimited quantities and used. The public, as a rule, knows nothing of the hazard they are bringing into their homes and factories in using such apparatus, with the result that numerous accidents, frequently fatal, occur from such use.

Unfortunately the development of the rules and regulations for electrical construction has taken place among the fire underwriters with the result that practically all rules are now designed to eliminate the fire hazard. Little or nothing definite has been accomplished toward the reduction of the life hazard, and this is daily becoming of more importance, as fatal electrical accidents are occurring entirely too frequently. Many municipalities have taken steps towards investigations along these lines, but before long some definite, concerted action will be necessary to formulate proper rules covering this subject. The City of Chicago has reports of 242 accidents occurring in 1913, 28 of which were fatal. Fifteen of these fatal accidents occurred to persons under 21 years of age, and many of them were the result of "dares" on the part of school boys. Of late years the number of accidents appears to be on the increase.

THE MEAN EFFECTIVE PRESSURE.

BY DANIEL ROESCH.*

The automobile of today is probably undergoing greater changes of design than at any other period in its history. Not the least of these is the change in the power plant itself.

This fact is emphasized by the steadily increasing number of new types of automobile engine now being exploited.

The relative merits of these various engines, as viewed from an engineering standpoint, are judged principally by power, fuel efficiency, oil efficiency, life, quietness of operation, flexibility and weight.

Probably the most important points to be considered are power and fuel efficiency. To a limited extent the relative fuel efficiencies may be disregarded since it can be shown that it is closely related and somewhat dependent upon the maximum power obtainable.

The brake horse power of a gas engine is the indicated horse power, less the various losses, viz: jacket loss, radiation loss, incomplete combustion loss, friction of the moving parts and mixture pumping loss and exhaust back pressure loss.

If the maximum power of a given size of engine is to be increased the first step is to perfect the "filling" and give the engine a greater weight of mixture per charge. Improvements along this line results in decreased fuel combustion per B. h. p. per hour because of the decreasing mixture pumping loss and also because the I. h. p. is increased faster than the friction of the moving parts of the engine. A specific case is recalled from the writer's experience during the test of a

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natural gas engine. Under normal conditions air and gas were supplied at atmospheric pressure.

By increasing the pressure of the charge to 10 pounds per square inch the resultant M. E. P. was about 180 pounds per square inch or nearly twice the normal. If air under 10 pounds per square inch pressure were cheap the arrangement would have been commercial. Another important factor in improving the B. h. p. of given engine is to overcome mixture troubles such as incorrect proportions of fuel and air, or the lack of homegeneity of the mixture. This fault result in a slow and spasmodically burning of the charge and is especially wasteful at higher piston speeds and with irregularly shaped combustion chambers. An improvement of this kind gives higher Mean Effective Pressures with the same amount of fuel per charge; that is, better fuel efficiency. Decrease of the friction loss, that of back pressure, or restricted intake passages give greater brake horse power for a given Mean Effective Pressure (i. e., given weight of charge) and therefore a decrease of the fuel used per brake horse power per hour.

It would appear, therefore, that the question of relative powers should be investigated primarily in studying the merits of various types of gasoline engines.

There are various angles from which the relative powers of different gasoline engines can be studied. One method used to a considerable extent, but now rather on the decline, is the method of comparing cubical contents only, without reference to the speed of the engine. This method is deficient in not taking into account the speed, or M. e. p. Since there is a wide variation in the M. e. p. of different engines and the M. e. p. of the same engine at different speeds, this method obviously will not furnish a true comparison, and moreover, does not take into account valve setting which becomes an important factor in the design of high speed engines. The factor influencing the M. e. p. of an engine is the relative weight of charge the engine can draw in, proper

proportion of gasoline to air, even distribution of the gasoline vapor in the mixture, proper point of ignition, proper position (or positions in multiple spark) of the spark in the combustion chamber for rapid flame propogation, and combustion chamber of as near spherical shape as possible, for least heat loss to the jackets.

The S. A. E. rating is a conservative one, based on cubical contents at a given M. E. P. Since it is a conservative rating and designed as such, most water cooled engines will give more power than that obtained by this formula. This excess of power is usually maintained at a considerably higher speed than the point determined by the A. L. A. M. rating; that is, 1,000 feet per minute, piston speed.

The method of comparison in this case is to plot the actual horse power speed curve of the engine being investigated, and on the same sheet the S. A. E. rating. The deviation of the actual horse power curve from the S. A. E. rating line represents the power excess or the power deficiency of the engine, depending on whether the actual horse power curve is above or below the S. A. E. line. This method would serve to compare any given engine with a standard performance—a performance which is usually easily equalled at the lower speeds but which is difficult to equal at the higher speeds of say, 1,200 to 1,600 feet per minute piston speed.

In case two engines are to be compared they must obviously be reduced to the same bore and stroke for a full comparison. The relative positions of their horse power speed curves will then determine their relative merits.

At the present time the tendency seems to be toward higher engine speeds and lower gear ratios. This condition has been made possible largely by the ability of a modern automobile engine to maintain nearly proportionally increasing power for increasing speeds to a point greatly in excess of that obtained a few years ago. This characteristic shows on the horsepower speed curve by its later deviation from a straight, or nearly straight, line. It is also shown by the torque curve which is a function of the horse power curve.

The torque curve is also a function of another curve that might be plotted. If, for instance, we desired to know the net M. E. P.; namely, the actual M. E. P. times the Mechanical Efficiency, we could compute it as follows, from the Horse Power or the Torque characteristic curve usually shown:

$$\text{H. P.} = \frac{PLAN}{33{,}000} \times \text{Mech. Eff.} \qquad (1)$$

where P=the Mean Effective Pressure in pounds per square inch

$P \times$ Mech. Eff. = Net M. E. P.

L=length of stroke in feet.

A=area of the piston in sq. inches.

N=number of explosions per minute.

Transposing

$$P \times \text{Eff. or P net} = \frac{\text{H. P.} \times 33{,}000}{L \times A \times N.} \qquad (2)$$

Or by a second method,

$$\text{H. P.} = \frac{2\pi R\, n\, W}{33{,}000} \qquad (3)$$

where

R=radius of brake arm in feet

W=net load on brake in pounds

$R\,W$=torque, usually expressed in ft. lbs.

R= 1 ft.

W=lbs.

n=number of revolutions per minute.

We then have from (3)

$$\text{H. P.} = \frac{2\pi n \times \text{Torque}_{\text{FT. LBS.}}}{33{,}000} \qquad (4)$$

From (1) above

$$\text{H. P.} = \frac{P_{\text{NET}} LAN}{33{,}000} \tag{5}$$

Equating (4) and (5)

$$\frac{2\pi n \times \text{Torque}_{\text{FT. LBS.}}}{33{,}000} = \frac{P_{\text{NET}} LAN}{33{,}000} \tag{6}$$

For the customary 4 cycle engine

$$N = \frac{n}{2} \times \text{No. of Cyls.}$$

$$L \text{ (in. ft.)} = \frac{l \text{ (in inches)}}{12}$$

$$A = 0.7854\ d^2$$

Substituting these values in the right hand member of (6) and simplifying we have

$$P_{\text{NET}} = \frac{191.5 \times \text{Torque}_{\text{(FT. LBS.)}}}{\text{No. of Cyls.} \times l \times d^2} \tag{7}$$

where (d) and (l) are the bore and stroke of the engine in inches.

If a number of tests have been made on an engine at different speeds, we have results resembling somewhat those of Table 1, which follows. This table represents the test of a four cylinder 4½-inch × 5-inch Tee head automobile engine on a Sprague Electric Dynamometer in the laboratories of Armour Institute of Technology.

The above results are shown graphically on curves (*A*) and (*B*), Fig. 1.

From Table 1 we can also compute, by means of equation (2) or (7), the net M. E. P. for the tests at the various speeds. An inspection of formula (7) shows that the net M. E. P. will be a constant times the torque for any partic-

TABLE I.

Speed of Engine R. P. M. (1)	Torque in Lbs. at 15¾" Radius (2)	Torque in Foot Lbs. $(2) \times \frac{15.75}{12}$	B. H. P. $\frac{(1) \times (2)}{4,000}$
410	128·8	169.0	13.20
533	135·0	177.2	18·00
640	137·5	280.0	22·00
802	137·75	180.8	27·60
951	135·3	177.8	32.2
1111	132·75	174.2	36.87
1302	122·0	160.2	39·80
1580	101·5	133.2	40.1
1690	91·5	120.0	38·70

ular engine, or, in other words, the net M. E. P. characteristic curve for an engine is the torque characteristic curve plotted to a different scale. In this particular example the constant will be

$$K = \frac{191.5}{4 \times 5 \times 4.5^2}$$

$$= 0.483 \times \text{Torque}_{\text{FT. LBS.}}$$

The computations for the M. E. P. $_{net}$ at the various speeds are given in Table II, as follows:

TABLE II.

SPEED	M. E. P. $_{NET}$
410	81.6
533	85.6
640	86.9
802	87.2
951	85.8
1111	84.1
1302	77.4
1580	64.4
1690	58.0

The M. e. p. $_{net}$ variations with speed are represented by curve, Fig. II, and this curve is of course identical with the torque characteristic except as to scale. It is of interest and M. e.p.$_{net}$ to note the maximum M. e. p.$_{actual}$ obtained

TABLE III.

Engine Speed, R. p. m.	Piston Speed, Ft. per min	H. P. to Drive Engine	B. h. p. Developed	Mechanical Efficiency	Actual M. e. p.
590	492	3.9	20.2	83.8	103.2
795	663	5.8	27.4	82.5	105.8
1045	872	8.7	35.1	80.2	105.9
1282	1069	11.4	39.5	77.6	100.5
1420	1183	13.0	40.6	75.6	96.0

and the falling off of the M. e. p. with rise speed. The M. e. p. $_{actual}$ can be obtained by dividing the M. e. p.$_{net}$ by the mechanical efficiency. The mechanical efficiency can be obtained quite approximately by noting the H. P. necessary to drive the engine at the various speeds and calling

this the friction horse power of this engine. This obviously gives a figure for mechanical efficiency that is too high,

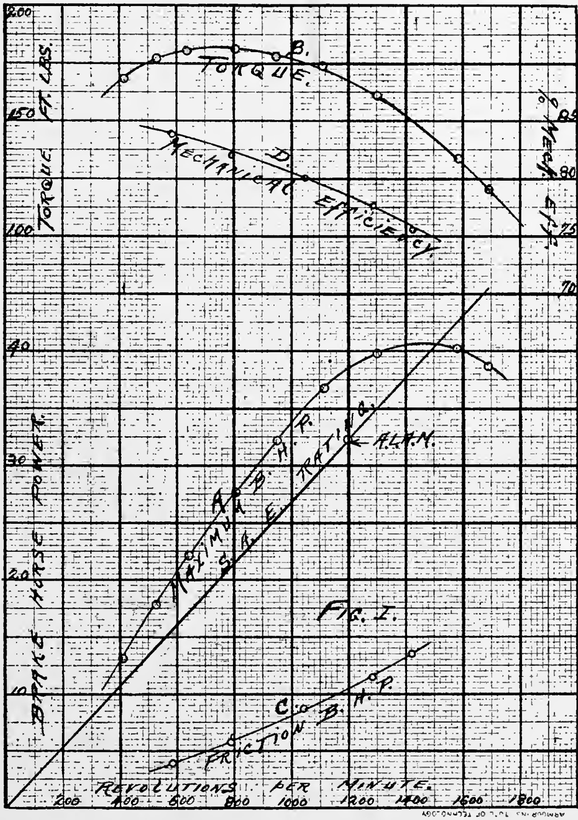

Figure 1

resulting in a computed M. e. $p._{actual}$ that is too low. The friction losses at the various speeds for this engine were

determined as above and shown by curve C, Fig. I. From this data the mechanical efficiency was calculated as follows:

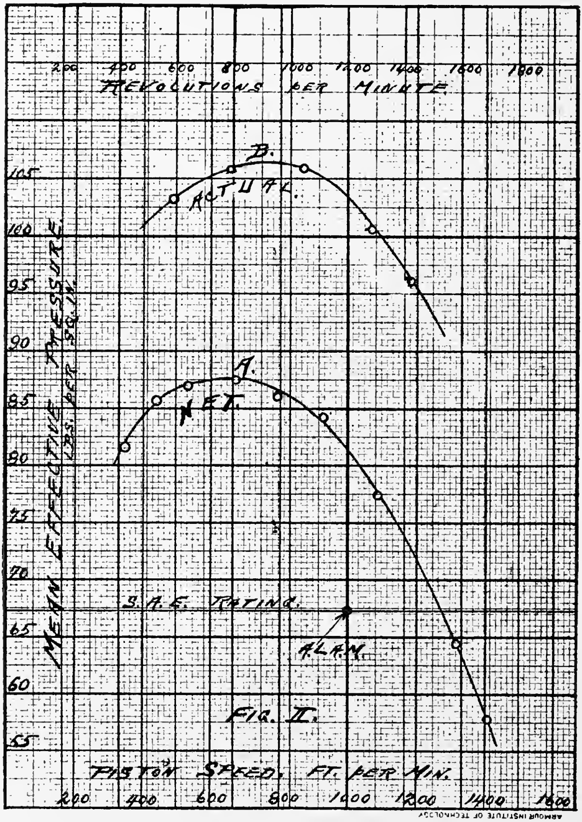

Figure 2

$$\text{Mechanical Efficiency} = \frac{\text{Brake Horse Power}}{\text{Brake H. P. and Friction H. P.}}$$

The Mechanical Efficiency curve is shown by Curve *D*, Fig. I, and the actual M. e. p. calculated by dividing the net M. e. p. by the mechanical efficiency. The latter is shown as Curve *B*, Fig. II, and the computations for the data of the above three curves are given in Table III.

EDDY CURRENT BRAKES.

BY H. W. NICHOLS, M. S., E. E.*

When a conductor is moved across a magnetic field it becomes the seat of induced motional electromotive forces which set up currents in the conductor. These currents, reacting upon the inducing field, produce a force tending to oppose the motion of the conductor, and if this motion is maintained by an impressed mechanical force, the moving system absorbs power from the source, which power is all dissipated in the form of heat in the conductor if the motion is steady. If the motion is not steady, some of the power is put into the electric and magnetic fields, and may be radiated away, but this effect is so small in practical cases that no account is ever taken of it.

This braking effect is used in watthour meters to produce a power absorption proportional to the square of the speed, and may be used to dissipate larger amounts of power, as in the absorption dynamometer. The peculiar advantages of the system are, that the counter torque may be readily controlled and measured, and that the moment of inertia of the moving part is small and there is no "chattering" or uneven torque. The low cost and weight are also points in its favor. For these reasons, it seems worth while to work out the general characteristics of such a system, aiming toward a few principles upon which to base the design of a given brake. The complete solution of this problem is difficult, and so far as I know, has never been attempted in particular cases except for those values of speed of the moving mass which

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are small enough to satisfy certain conditions to be mentioned later. But it is exactly these unsolved cases which are of engineering importance, for the critical speed in a good conductor is comparatively low. Thus, in this paper, I shall solve the problem exactly for small speeds and certain commercial arrangements of conductor and field, and then attempt to find what modifications are necessary in order to pass to the case of practical speeds, going upon the supposition that a knowledge of the characteristics of the machine is better than nothing at all.

The particular case considered is that of a thin sheet of metal moving between the poles of a magnet, so that the impressed flux due to the magnet cuts the sheet inside a curve C, enclosing an area S. The flux inside S will be supposed uniform (a least in this paper) and the area S rather small compared with the area of the sheet, so that the edges of the latter exert no controlling influence upon the solution. Let the impressed magnetic force *vector* be H_0, the permeability and inductivity of the sheet, μ and ϵ, and the vector of velocity, v. Then, due to the motion across the field, an electric force will be produced, equal to $\mu\, v\, H_0$, perpendicular to the velocity and the field, and under the influence of this impressed force, currents will exist in the sheet, producing another magnetic field, h. This field will combine with the original field to produce a resultant field H, not confined to the area S. Thus, as soon as currents begin to flow in the sheet, there will be an induced electric force at other parts of the sheet also, produced by the "armature reaction," h, and this will distort the current lines and complicate the problem. When the speed or conductivity of the sheet is small, the armature reaction will be also, and the solution is quite simple. It will give the undistorted current lines, and then we may (possibly) estimate the effect of the distortion or eliminate it, and obtain the complete solution.

Let E be the electric force at any point of the sheet, and c its conductance: then, using the notation of Vector Analysis,

the appropriate forms for the two Maxwell equations are, omitting a few mathematical steps:

$$curl\ (H - H_0 - \epsilon E \times v) = c\ E$$
$$curl\ (E - \mu v \times H) O = O,\ div\ H = O$$

Here Heaviside units are used, so that the factor 4π does not appear. From the second of these, it follows that $E - \mu v \times H$ is irrotational, and hence may be written as the gradient of a

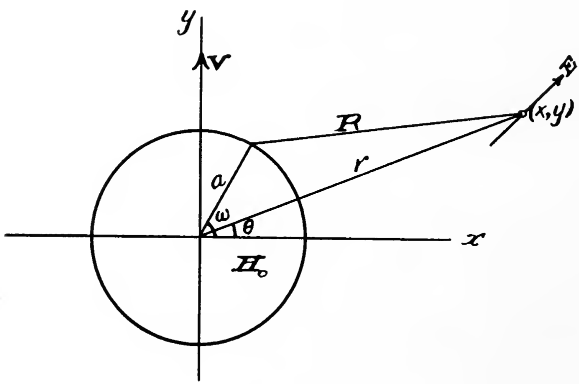

Figure 1

scalar ϕ. This scalar potential is then determined from the equation

$$\phi = \frac{1}{2\pi} \int \mu (v\text{-}curl\ H - H \cdot curl\ v)\ log\ R\ dS$$

where R means the distance from the element dS to the point (x,y) at which ϕ is taken, and the integration is over the whole sheet. The electric force at any point in the sheet is then,

$$E = \mu v \times H - grad \phi$$

The current at that point is c times this electric force, the mechanical force is

$$f = \mu c \ E \times H,$$

by Ampere's law, and the power absorbed in the unit volume at that point, $f.v.$ Hence, to get the total braking effect, it is only necessary to integrate the last expression over every part of the sheet in which H is not zero.

The potential ϕ may be found as soon as the armature reaction h is known, and the problem is then perfectly simple. Unfortunately, however, the determination of h is not simple, so that we begin with the case in which the speed is small enough to allow us to neglect it.

To illustrate, suppose the pole pieces are circular, of radius a, and that the origin is taken at the center. Let the speed v be parallel to the y-axis, and the inducing field to the z-axis, the arrangement being as in the first figure.

Now, H_0 has a curl only on the circumference of the circle, and there $v.curl\ H_0 = v\ H_0 cos\omega$, hence

$$\phi = \frac{\mu v\ H_0 a}{2\pi} \int_0^{2\pi} d\omega \ \underline{log}\ R\ cos\ \omega$$

This integration is performed by the usual method of expansion of the logarithm in harmonic functions, and gives the result, for points *inside* the circle·

$$\phi = \tfrac{1}{2} \mu v\ H_0 x$$

For points outside:

$$\phi = \tfrac{1}{2} \frac{\mu v\ H_0\ a^2 x}{r^2}$$

Hence the components of electric force are, inside the circle:

$$E_x = \tfrac{1}{2} \mu v\ H_0 \qquad E_y = O$$

and for points outside:

$$E_x = \frac{\mu a^2 v\ H_0}{2r^2} cos\ 2\theta \qquad E_y \frac{\mu a^2 v\ H_0}{2r^2}\ sin\ 2\theta$$

The undistorted current lines are thus circles with centers

on the y-axis outside the circle, and inside are straight lines. The map of the field is shown in the second figure.

We may now solve several problems. In the first place, the braking effect is found by integrating

$$\mu c[E\ H_0\ v]$$

over the circle under the pole faces. But since this expression is constant, the total power absorbed is

$$P = \frac{\pi a^2 c \mu^2 v^2 H_0^2}{2}$$

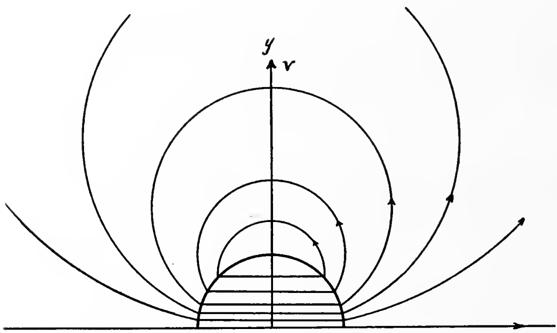

Figure 2

in electromagnetic units (absolute), or, using practical units:

$$P = \frac{\pi a^2 c \mu^2 v^2 H_0^2}{2} \times 10^{-16} \text{ watts.}$$

The total current producing this effect is found by integrating $c\ E$ across a diameter of the circle perpendicular to the current; it is:

$$I = 10^{-8} c \mu a v\ H_0 \text{ amperes}$$

and the closs-magnetizing *m.m.f.* due to this current is $0.4\pi I$

gilberts. Its effect is to strengthen the field under the "leading" pole tip, and to weaken it under the other.

As an example of the magnitudes to be expected, assume a polar radius of 2 centimeters, a flux density of 2,000, speed 500 centimeters per second, and a copper sheet of thickness 2 millimeters. The specific resistance of copper is 1.7×10^{-6} so that c is approximately 1.2×10^{5}. This gives a power absorption of 75 watts, or a tenth of a horse power.

The current density under the pole face is 600 amperes per centimeter length, and the total current, 2,400 amperes, producing a *m.m.f.* of 3,000 gilberts. But this is large, so that the conditions of the problem are violated, and the solution does not apply exactly. We can lessen the effect of this armature reaction by slotting the magnet in planes parallel to the x–axis.

Since the impressed field enters as the square it is better to use higher flux densities and lower conductance in the sheet, but it is apparent that account must be taken of the armature reaction if any considerable amount of power is to be absorbed. The effect of the reaction is to deform the circles of current somewhat, and to shift them forward in the direction of motion. There will thus be a demagnetizing action, and a preliminary investigation shows that the resultant field in the air-gap will fall off asymptotically with increasing speed. These results, together with an experimental study of the electric brake I hope to present later.

THE ELASTIC LIMIT BY TEMPERATURE MEASUREMENT.

BY JAMES CLINTON PEEBLES.*

When a solid body is subjected to the action of an external force a certain deformation is produced. If the body be of elastic material it is well known that the deformation or strain produced is proportional to the load or stress applied. If a tensile stress be applied to a piece of steel for example, the specimen will undergo an elongation or longitudinal deformation proportional to the stress applied.

It is also a fact of observation that when such elongation takes place the body contracts laterally about one-fourth of its proportionate elongation. This ratio of lateral to longitudinal deformation is known as *Poisson's Ratio,* and is approximately constant for nearly all the metals.

Assume for example a steel test specimen of length l, width w, and thickness t. Let λl be the increase in length of the piece of steel under the action of a tensile stress P. The final length will then be $l(1+\lambda)$. The width will be decreased by $\frac{1}{4}\lambda w$, and will become $w(1-\frac{\lambda}{4})$. Similarly the thickness will be $t(1-\frac{\lambda}{4})$. The volume of the specimen will be:

$$v_1 = l(1+\lambda)\times w(1-\frac{\lambda}{4})\times t(1-\frac{\lambda}{4}) = l\,wt(1+\frac{\lambda}{2}-\frac{7\lambda^2}{16}+\frac{\lambda^3}{16})$$

Inasmuch as λ is a very small quantity the terms involving

*Class 1904, Assistant Professor of Experimental Engineering, Armour Institute of Technology.

the square and the cube may be dropped, and the volume of the specimen while under load becomes $v_1=lwt(1+\frac{\lambda}{2})$.

But the original volume $v_0=lwt$, and hence the change in volume is $lwt\frac{\lambda}{2}$. Thus the specimen has undergone an *increase* in volume, the relative expansion being the increase $lwt\,\frac{\lambda}{2}$ divided by the original volume lwt, $=\frac{\lambda}{2}$

Therefore the volume has been increased by one-half the percentage that the length was increased. A 10 per cent increase in length of a specimen under test means a 5 per cent increase in the volume.

It is a well established fact in thermodynamics that when any change of state is brought about in a system or body through the action of external forces, a certain amount of

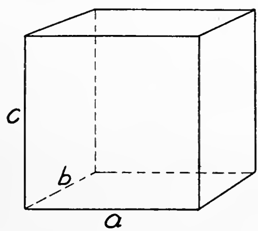

Figure 1

heat will be absorbed from surrounding bodies. This heat may be positive or negative, depending upon the nature of the body, heat taken up being considered positive.

Let the steel test specimen mentioned above be such a body and let *a, b, c,* Fig. 1, be a rectangular volume-element of the piece. Suppose that a tensil stress P is applied parallel to the element *a,* the resulting increase in length being λa. The resulting increase in volume of the element *a, b, c,* will be $a\,b\,c\frac{\lambda}{2}$, as explained above.

Now the heat absorbed in this expansion may be expressed in the form $H=K\,a\,b\,c\frac{\lambda}{2}$, in which K may be defined as the latent heat of expansion of the material in question, for constant temperature. The term latent heat as used in this connection is suggested by the fact that no temperature increase

takes place during the absorption of heat. It should not be confused with the term *latent heat of transformation* used in connection with the passage of the material from a solid to a liquid or from a liquid to a gas.

In order to calculate the amount of heat absorbed it is only necessary to know the dimensions of the test specimen, and the values of K and λ respectively. The determination of λ involves only a measurement of the elongation, while K may be calculated from certain well known relations. By definition K is the ratio of the heat absorbed by a unit mass of the substance to the increase of volume, if the temperature remain constant. Or, expressed mathematically we have

$$K = \left\{ \frac{dl}{dv} \right\}_t$$

Suppose now that a certain mass $d\,m$ of this substance passes from one state or phase to another, say from the solid to the liquid state. Let v_0 and v_1 be the specific volumes in the solid state and liquid state respectively. Then the heat absorbed by the mass $d\,m = S\,d\,m$, where S is the latent heat of fusion. The increase in volume $d\,v = (v_1 - v_0)\,d\,m$, and K equals

$$\frac{S\,d\,m}{(v_1 - v_0)\,d\,m} = \frac{S}{v_1 - v_0}$$

That is, the latent heat of expansion equals the latent heat of transformation divided by the increase in specific volume undergone during the change of state. Thus if S is known for any particular substance, K can be calculated.

It can be readily shown that K is positive for any substance which expands when heated. Thus for practically all solids heat is taken up from the surroundings whenever work is done upon the substance by means of external force. Furthermore, the amount of heat absorbed can be calculated quite readily, as already shown.

While the sample of steel mentioned above is under test it receives an amount of energy equal to the sum of the mechanical work done upon it and the heat absorbed. If

the process is a cyclic one, that is, if the specimen will return to its original state after the removal of the load, the energy received in the first half of the cycle will be given up again during the second half. This follows directly from the first law of thermodynamics. But if the process is not a reversible one the body will not return to its original state.

If then, the steel specimen be subjected to a tensil stress heat will be absorbed from surrounding bodies. If the load is applied slowly the resulting expansion will be practically isothermal, sufficient heat being absorbed to maintain the temperature constant. If, however, the load be applied more rapidly and the specimen be insulated so that heat cannot be absorbed from the surroundings, the expansion is practically adiabatic and the specimen is cooled.

If the specimen be stretched beyond the elastic limit the process is no longer reversible and the energy returned on the removal of the load is less than that supplied. The lost energy appears as heat in the test specimen and a marked increase in the temperature results.

These considerations suggest the feasibility of determining the elastic limit of steel or other elastic material in tension by means of a temperature measurement. If the specimen be lagged so that heat cannot be absorbed from surrounding bodies, the temperature of the piece will fall until the elastic limit is reached, after which it will rise. Thus the temperature change reverses from positive to negative at the elastic limit, and if a prompt and continuous indication of temperature can be secured an accurate method of determining the elastic limit is at hand.

For the purpose of indicating the temperature changes a copper-constantan thermo-couple was used, connecting to a reflecting galvanometer. The test specimen was of mild steel, ⅝ inch in diameter, and carefully lagged to prevent the absorption of heat from the surrounding air. The junction of the thermo-couple was placed in a groove cut in the specimen, the groove having been painted with a thin coat of shellac to prevent direct metallic contact between couple and steel.

When the load was applied the galvanometer deflected slowly to the left, indicating a cooling. At a reading of 5

mm. on the scale the deflection reversed and rose rapidly in the other direction, finally passing off the scale. The reversal of the galvanometer coincided almost exactly with the drop of the beam of the testing machine, indicating the elastic limit.

Under the conditions of the test the galvanometer gave a deflection of approximately 25 mm. per degree F., so that the cooling of the specimen was approximately 1/5 degree F. Special precautions were taken to prevent temperature changes at the outer end or cold junction of the thermocouple, because its indications depend not upon the absolute temperature of the hot junction but upon the difference in temperature between the two ends.

A second test was made using a piece of boiler plate 1½ inch wide and ⅝ inch thick. The thermocouple was placed in a hole drilled to the center of the specimen. In this case the test piece was left unlagged in the hope that a larger specimen and a more rapid rate of pulling would show a certain amount of cooling at the center, even although some heat were absorbed from the outside. In this case a negative deflection of 11 mm. was obtained, showing a cooling at the center of approximately 0.44 degrees F. This was followed by a rapid heating, the specimen becoming warm to the touch.

These experiments indicate that it is possible to determine the elastic limit directly and with considerable accuracy by means of the temperature measurement. It may even be possible in certain cases to make the test specimen itself one of the elements of the thermocouple, which should simplify the method somewhat.

Further experiments are contemplated along this line.

THE PROGRESS OF THE CARBON DIOXIDE INDUSTRY.

BY JULIUS GEORGE HATMAN.*

Carbon dioxide or carbonic acid gas was discovered in 1757 by Dr. Black. Afterwards various experiments to determine the physical and chemical properties were carried on by well known scientists such as Thilorier, Dorlhac and Saminn, Lavosier and Faraday. Its properties as an extinguisher of fire, a food preservative and refrigerant have been known for some time and a great number of experiments have been carried on, but most of the results are to be found only in German, Italian, French and Swedish, very little work being done in this country. Carbon Dioxide is found in air in proportion of about $\frac{4}{10000}$ and is produced throughout nature in immense quantities. The average adult exhales 8 ounces daily. There are numerous carbon dioxide springs in the United States and Germany, the most notable in this country being at Saratoga Springs, N. Y. Mixed with ether, a great degree of cold, 166 degrees F. below zero, has been reached. This can be more easily understood when this mixture was evaporated in the open air it froze ten pounds of mercury in less than six minutes.

The critical temperature of carbon dioxide is 88 degrees F., and this fact has been regarded by refrigerating men as a detriment, although with condensing water above 85 degrees F. vessels steaming in the tropics have very good results.

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*Class 1910, Engineer, The Osborne Process Liquid Carbonic Company, Kansas City, Mo.

The specific gravity of carbon dioxide is 1.529 referred to air. Its boing point is 109 degrees F. below zero. The specific heat at constant pressure is .2167; at constant volume .1714,

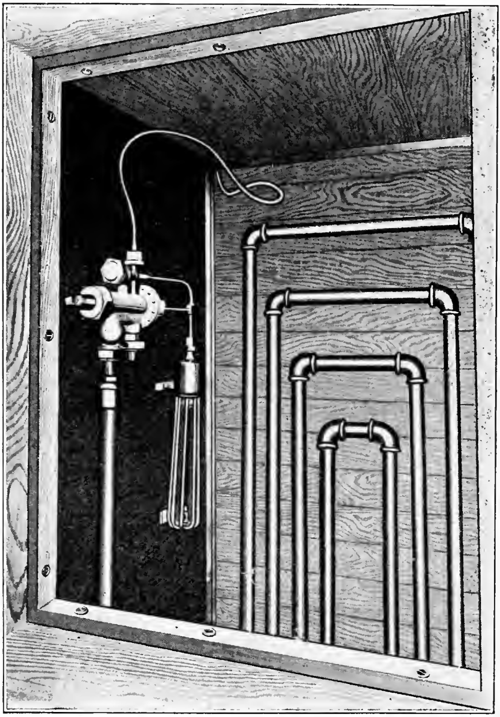

Figure 1. Automatic Valve and Thermostat.

and of the liquid .79. At 32 degrees F. the specific weight is .947 and latent heat of vaporization 100 B. T. U.

Carbon dioxide as sold on the market at the present time is produced by drawing it off from beer vats in breweries, and

purified chemically. The cost of doing this is expensive. One pound of liquid CO_2 is given off by every five to six gallons of beer malt during fermentation. The Osborne Process Liquid Carbonic Company by calcining limestone and separating mechanically produces it at a very small cost. This mechanical separator operates in the same manner as a cream separator. The component gases as they enter the separator

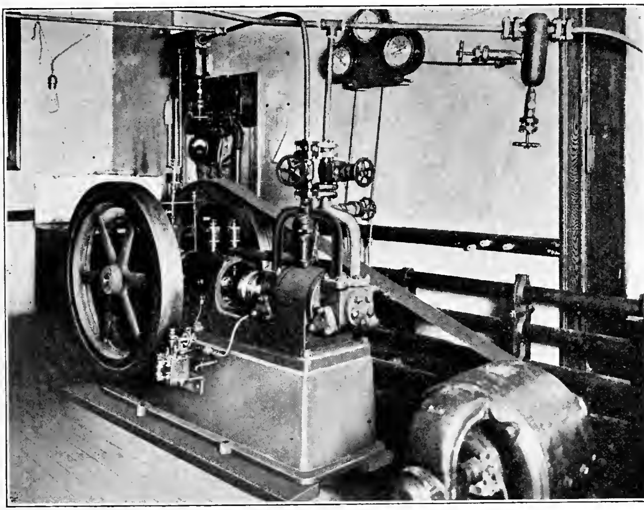

Figure 2. Two-Ton Compressor.

from the kiln and their specific gravities are:

CO_2—1.51	CO	Nitrogen—.973	O_2—1.1
54%	trace	43%	3%

From which it can be seen that under Mariotte's law these gases can be readily separated mechanically. The facility with which lime is burnt depends of course on the porosity of the lime. The carbon dioxide can be accelerated by intro-

ducing steam, during the burning. This Company uses a gas producer, lime calcining tower and steam boiler for its primary effect. From the calcining tower the combined gases are passed through a washer and scrubber which is a series of sieves or perforated pans. The lower pans are filled with coke and the upper ones with spongy iron. This removes any sulphur compounds which enter with the dioxide. From the washers the gas passes to the separator which sets in a horizontal position. The carbon dioxide together with a small per cent of lighter gases passes from this separator to a holder which is similar in construction to the ordinary gas holder except that ours has a valve in the top where this remaining small per cent of lighter gases escapes. From the holder the gas is drawn off and liquefied by three stage compressors and the tanks are filled for commercial use. From the decomposition of coal and limestone in the above plant carbon dioxide, pure lime, coke, coal tar, carbonates of ammonia, sulphur and illuminating gas, are produced, all of which have a market value and are in demand daily.

2000 lb. limestone	will yield	1120 lb. lime.
		800 lb. CO_2
2000 lb. coal	will yield	700 lb. coke
		2¼ lb. sulphur
		45½ lb. carbonate of ammonia
		10 gal. coal tar
		4516 cu. ft. gas

By our process CO_2 can be produced very cheaply for two reasons: One is that it is obtained as a by product and the other is the mechanical separation of the gases.

The liquefying of CO_2 requires 7 I. H. P. per ton in 24 hours, or using coal at $1.62 per ton it costs $ .41 to liquefy one ton of CO_2.

The superiority of carbon dioxide as a refrigerant needs no explanation to the technical man. The navy is at present equipping its battleships with dioxide refrigeration. All gases when compressed, liquefied and expanded, will produce refrigeration and natural gas has been used for that purpose

in practice. The difference in refrigerating effect can be easily understood with the following illustration. Take a cylinder of 160 cu. ft. capacity. This will contain in liquid form about 8000 pounds of CO_2 and have a refrigerating effect equal to melting of 7500 pounds to 8900 pounds of ice. The same cylinder with compressed air at 800 pounds pressure will contain only 670 pounds of air and have a refrigerating effect equal to melting 24.7 pounds of ice. In compressing gases they obey Boyle's law and compressing carbon dioxide from 50 to 60 atmospheres (about 800 pounds) we get a reduction in volume of 435 times. Making the same compression in air we would have a pressure of 6300 pounds per square inch, which would be about 5300 pounds of air having a refrigerating effect equal to melting of 215 pounds of ice.

Compression Data.

CO_2	62° F.	14.7 lb. per in.	8.616	cu. ft. per lb. vapor
	62° F.	764.5 lb. per in.	.02006	cu. ft. per lb. liquid
		429.5 reductions in volume		
Air	62° F.	14.7 lb. per in.	13.141	cu. ft. per lb. gas
	62° F.	6313. lb. per in.	.030596	cu. ft. per lb. gas

or 32.2 times as much refrigerating effect in carbon dioxide than air. Theoretically the efficiency of the CO_2 system is 12 per cent less than ammonia or sulphur dioxide, but in practice it has been found that the losses sustained in radiation in the refrigerator, resistance in passage of the gases, piston and valve leakage average 48 to 50 per cent in the ammonia and sulphur dioxide and only 25 per cent in the carbon dioxide. Piston leakage alone averages 25 per cent in the ammonia and 9 per cent in carbon dioxide. Frictional losses in suction line is small in the CO_2 machine. The practical over the theoretical therefore must be enlarged nearly 50 per cent for ammonia and sulphur dioxide and 25 per cent for the carbon dioxide, which more than offsets the 12 per cent theoretical efficiency.

Refrigerator cars which are now cooled entirely with ice can by using the Osborne system be refrigerated with CO_2

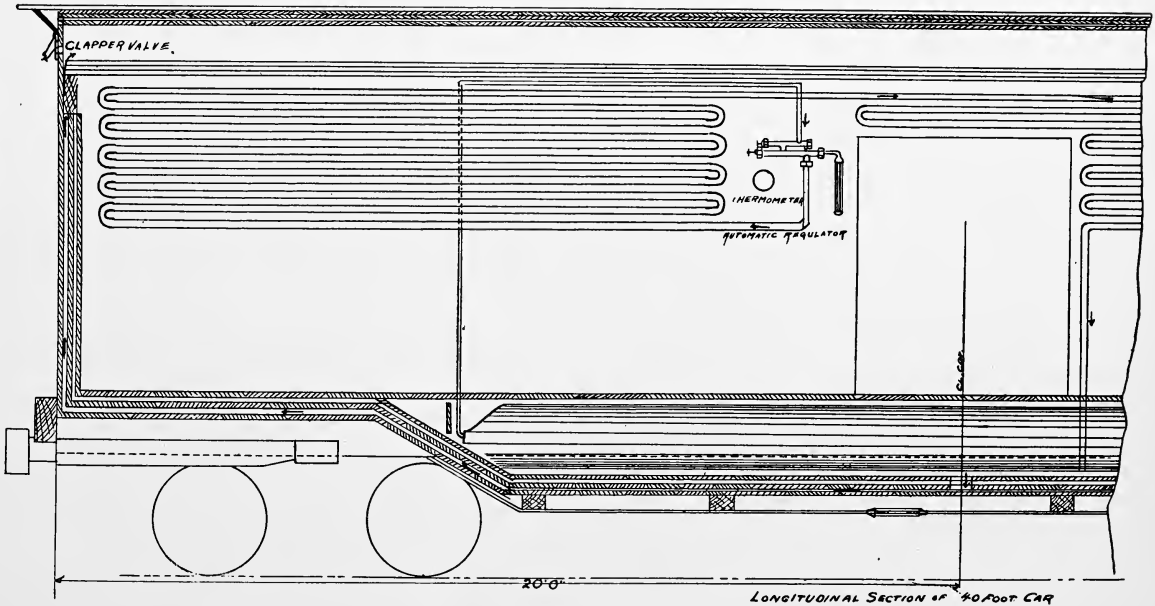
CLAPPER VALVE.
IHERMOMETER
AUTOMATIC REGULATOR
20'0"
LONGITUDINAL SECTION OF 40 FOOT CAR

Figure 3

by carrying tanks under the car. The Osborne valve can be set at any desired temperature and the thermostat will maintain that temperature within two degrees at all times. At present it costs $60.00 to ice a car from Texas to Kansas City. By using this system $10.00 or $12.00 will do the same work. For this class of service ammonia cannot be used, as the continual bumping of cars will in time cause leaks which always occur when least expected, and the fluid used will get on the products in the car. Ammonia will immediately spoil any food product. Carbon dioxide being the natural food for all vegetation will tend to preserve whatever it comes in contact with. A car with this equipment was built and with the outside temperature 90 degrees F. a temperature of 35 degrees F. was maintained inside the car for 5¼ days, and with the outside at 70 degree F. the inside was maintained at 35 degrees F. for 7¾ days and with 50 degrees F. on the outside, the inside was at 35 degrees F. for 16½ days, each test having one charge and each charge being the same. There are now in use about 60,000 refrigerator cars and twenty million dollars is expended yearly in ice for this purpose. Each car carries 2¼ tons and it must be loaded with ice 24 hours before using, so as to have the car cool when loaded. The cost of precooling cars is several million dollars yearly. At the end of the journey whatever ice remains in the car must necessarily be wasted while with the carbon dioxide system the supply can be shut off and saved till the next trip. Also the pre-cooling of cars will be shortened, as for the most severe case one hour's cooling is sufficient, and in most cases the supply will not be turned on till after the car is loaded. This means that more cars will be available daily. The annual losses from salt water dripping to rails, ties and cars is several million dollars. One of the large railway systems of the east estimates this loss at ten million dollars per year, while one of the smaller systems in the middle west say over one million dollars.

The use of carbon dioxide as a fire extinguisher has been known for a long time. The chemical wagons of the fire

department and the fire extinguishers in small copper tanks in the hallways of large buildings are quite common. At the present time reports from fire insurance companies show that 90 per cent of their loss is water loss. The various sprinkler systems in use in factories, etc., use water and naturally, even if a fire is prevented, there is always some loss incurred by water. By using the carbon dioxide automatic

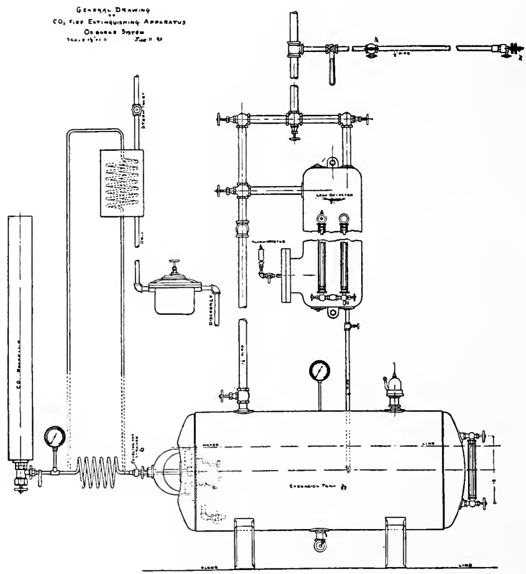

Figure 4

fire extinguisher this loss is prevented. Actual tests were made in three places: Sutter Brothers, corner of Lake and La Salle streets, Chicago, and Illinois Central Car Works building, 2533 South Park avenue, Chicago, and Senderhauf Soap Factory, Milwukee. The equipment in each place worked perfectly numerous times.

Three large tanks six feet by six feet and filled with six inches of denatured alcohol were lighted and from the time the attendant applied the torch to the last tank to the time he reached the door the fire was out. Rabbits eating cabbage in the room where these tests were conducted never stopped their operation and did not seem affected in the least. This shows that with 1/10 the respiratory powers of the human body animal life existed. Furthermore, there was no damage of goods or other material not directly in contact with the flames. As soon as the fire is extinguished and the room attains somewhere near normal temperatures the valve automatically closes, the room is in exactly the same condition as before and all that is necessary is to open the window and allow the dead gases to escape.

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TERMS OF SUBSCRIPTION.

THE ARMOUR ENGINEER, four issues, postage prepaid........$1.00 per annum

The executive council of Armour Institute of Technology have appointed the following men as members of the staff of *The Armour Engineer* for the school year, 1914-1915.

C. A. Knuepfer—Editor-in-chief.
Charles W. Brittan—Managing Editor.
A. N. Grossman—Business Manager.
Walter H. Rietz—Associate Business Manager.

We ask the readers of this journal to join us in a hearty welcome to the incoming staff.

For years I have taken a great interest in talking with college graduates for the purpose of endeavoring to ascertain why some win, while others fail, in the battles of life.

It has often been remarked that the prizes of life often come to those whose record at college was perhaps not a brilliant one, while those who seemed to have great natural gifts and who stood at the head of their classes often remained behind in the race. At times men of inferior education have succeeded where men of the highest training failed.

At twenty years of age George Stephenson could neither read nor write, yet he became the inventor of the locomotive. When a boy, James Watt was often scolded by his grandmother for neglecting books and idling away his time by playing with the tea kettle. Arkwright, the inventor of the spinning jenny, who helped bring on the greatest industrial revolution in history, was in his youth a barber's apprentice. Henry Ward Beecher was the last boy in his class. Goldsmith was regarded as a dunce by his friends and neighbors and failed ignominiously as a physician. Sir Walter Scott and Robert Clive were both considered blockheads at school. Wellington was the last boy at Eton of whom anything was expected. The father of John Wesley often asked the boy's mother, "Why do you tell that blockhead the same thing twenty times over?" At thirty Grant seemed a hopeless failure, but at forty-one he had become one of the world's greatest generals.

Do such cases disprove the value of an education? Not in the least. They simply show that an education is not a fetisch, but only a means to an end. All that an education can do is to put tools in your hand. Whether you use them or not depends upon you. How often, to use David Starr Jordan's expression, "a five-thousand dollar education is wasted on a fifty-cent boy." "When God endowed human beings with brains," said Montesquieu, "he did not intend to guarantee them." While "knowledge is power," this power must be applied to be of any value. Theories are splendid things, necessary things, but they must be put into practice.

A diploma is not a passport to success. Too often the attaining of a degree is regarded as the finishing of education. The graduate, like Byron, hurls his books into the corner with the words, "Farewell, Horace, whom I hated so."

For many, graduation from college means arrested development. They expect the world to render homage to them. Like the cock of whom George Eliot speaks, they think the sun rises in the morning to hear them crow.

A college education is but a preparation for the school of life. The hardest problems still remain to be solved. The essential thing is for the college man to learn how to adjust himself to this new environment. He will certainly fail if he is not ready to roll up his sleeves and work in the sweat of his brow. As Garfield said, "Things don't turn up in this world until somebody turns them up." Let the college man be prepared to receive many hard knocks. Let him take pleasure in surmounting obstacles, in doing things because they are hard. Let him remember that—

"Life's no resting, but a moving,
Let thy life be deed on deed."

If he is ready to find pleasure in hard work his education, far from being a handicap, will enable him to mount the ladder of success all the more quickly. Training of the right sort does not give a crutch, but it gives wings.

—*George L. Scherger.*

The earnest student is always on the lookout for general principles which will give him a key to the undiscovered mysteries of nature. With these general principles he is able to predict what will happen in new and untried situations. Thus prediction becomes the aim and test of true science.

The engineer's problems are such that they cannot be settled by custom, tradition or on authority. Even Bacon recognized this when he defined education as the cultivation of a just and legitimate familiarity betwixt mind and things. Laboratory courses will give the student little of permanent value unless he acquires the true method, which is the scientific method. Not only is the scientific method more important than the subject matter, but it is the only method that is fruitful in any subject.

Action and reaction make for progress not only in the devel-

opment of scientific industries but also in the education of the engineer. Pure theory should become an aid to sound practice. If theory is right and practice does not agree with it so much the worse for practice.

Facility in adapting ones self to new studies, to changing conditions, or to different problems distinguishes the man of progress. Ten years hence many of the methods now used by the industries will be succeeded by better ones. The machines now looked upon with wonder by the novice will then be relegated to the scrap heap.

One of the broadest generalizations and one which seems to have an application to every science is what is known as the *Principle of Least Action*. Biologists including botanists and zoologists are realizing the need for the rapid extension of physical methods to their science and are beginning to recognize the applicability of this law. In its broadest form it may be stated as follows: "A system tends to change so as to minimize an external disturbance."

Professor Bancroft, a chemist, sees in this principle not only an explanation of temperature, pressure, concentrations, electricity and light, but also of the phenomena connected with moisture, food, secretions, and climate, even to the determination of the color of different races of men. President MacLaurin of the Massachusetts Institute of Technology, a physicist, has based his treatise on the Theory of Light upon this one principle.

It is almost axiomatic that light takes the shortest time between two points. In fact, in air this gives us a physical realization of a straight line or of a straight as the mathematician calls it. The extension to reflection, refraction, and other optical phenomena increase the difficulties, but it is easily shown that Fermat's principle is a special case of that of Least Action.

One great handicap that many students have is at the threshold of knowledge. Their senses are not properly developed. This is lamentably true of the sense of touch not to mention the sense of smell, sight and hearing.

Pasteur remarked, "In the field of observation chance favors only the mind which is prepared," and Leonardo's maxim

was, "You must know it is only the eyes gained by knowledge that can see."

To make the extension somewhat complete it is needful merely to mention the large group of facts classed under the law survival of the fittest and in economics the law of supply and demand. Even theology is not exempt from the dominion of this principle. Bishop Butler's Anology is a peculiarly cogent line of reasoning to receptive minds but to the skeptic it is very vulnerable to attack.

One of the points to be steadily borne in mind in all plans for educational progress is that "mental assimulation is a matter of consciousness." So says John Dewey, the great psychologist. Every avenue of mind and sense and heart must be receptive to the best impressions then the will must be exercised in conscious volition to make right selection.

"The cultivation and training of the practical ability to do things and to learn from observation, experiment, and measurement, is a part of education which the clergyman and the lawyer can may be neglect, because they have to deal with emotions and words, but which the doctor and the engineer can only neglect at their own peril and that of those who employ them."—G. F. Fitzgerald.

Finally, the incalculable benefits arising from the work of such men as Michael Faraday should not only be thoroughly appreciated but the lesson they teach should be mastered in detail. They strove unselfishly to extend the bounds of knowledge hampered though they were by tardy recognition and inadequate support. Who would have dreamed in Faraday's day that a singe industry which he made possible by his researches would require a capital of eight million dollars a week. His attitude of mind is shown by a quotation, "I will simply express my strong belief, that that point of self-education which consists in teaching the mind to resist its desires and inclinations, until they are proved to be right, is the most important of all not only in things of natural phylosophy, but in every other department of life."

"The hope of the country lies in these young engineers—the aristocrats of the future."

—*Thomas Eaton Doubt.*

ARMOUR INSTITUTE OF TECHNOLOGY BRANCH OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

The fifth meeting of the Mechanical Society was held March 4th in the Physics lecture room. The election of officers for 1914-1915 took place and the following were elected:

President—Fred L. Brewer, Jr.

Vice-President—O. A. Anderson.

Secretary—Jess A. Agee.

Treasurer—W. L. Juttemeyer.

After the election, Mr O. Goetz, '14, gave a talk on "Kerosene Carburation," and Mr. L. W. Close, '15, talked on "Vehicle Springs."

The next meeting was held on April first. "Modern Boiler Room Operation" was the subject of the talk given by Mr. Blonck. In his talk, Mr. Blonck, who is president of Blonck & Co., explained the principles of the boiler efficiency meters made by his company. By means of efficiency curves taken from large power plants he pointed out some causes of defects in the operation of boilers. The talk was very interesting and instructive.

—*J. A. Agee.*

ARMOUR INSTITUTE OF TECHNOLOGY BRANCH OF THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

The first February meeting took place on the 25th in Chapin Hall. Papers were given by F. A. Swanson, '14, on "Multiple Unit Control," and by J. R. Charlton, '14, on "The General Electric Test Course." The paper by Mr. Swanson dealt with the various types of multiple unit control used in this country by the various electric roads operating more than one car in their trains. Mr. Charlton gave a general outline of the test course given by the General Electric Co., to

give young men a thorough idea of the many departments in their factories.

On March 10th, a paper was given by C. F. Wright, '15, on "Lightning Arresters." This covered the many types of lightning arresters and the methods used in protecting apparatus.

On March 24th, a paper was given by H. A. Mammes, '15, on "Electric Furnaces." This included a short history of the use of electricity for this purpose.

The annual banquet was held on April 29th at the Boston Oyster House. After the banquet, election of officers for the coming year was held, the following men being elected:

Chairman—W. F. Burroughs.
Secretary—C. F. Wright.
Treasurer—F. F. Adamson.

Informal talks by the Seniors of their thesis subjects, followed after the business matters were finished.

—*M. V. Stecher.*

ARMOUR CHEMICAL ENGINEERING SOCIETY.

Only two meetings of the society have been held since the last issue of the *Engineer.*

On the 23rd of March, the society was entertained by J. J. Schommer, '12, in his talk on "Vinegars and Commercial Adulterants." Not only did he speak on the chemistry involved but also gave some interesting facts regarding the "inside workings of the Trust. Mr. O. A. De Celle, '14, spoke very interestingly of his work at Joliet during the past summer on "Water Softening for the Manufacture of Artificial Ice."

The last regular meeting of the society for this year was held Monday evening, April 13th. The important official business of the evening was the election of officers which resulted as follows:

President—R. D. Parrott, '15.
Vice-President—G. A. Perlstein, '16.
Secretary—C. A. Congdon, '15.
Treasurer—A. N. Grossman, '15.
Chairman of Program Committee—E. D. Gothwaite.

After the election, Harris Perlstein, '14, gave a very good discourse on "Photo-Engraving," describing each step from the preliminary to the final operation and illustrating the process at various points by well chosen specimens.

The Social Committee has announced that the Annual banquet will be held May 20th, at the Railway Supply and Equipment Club, eleventh floor of the Karpen Building. This will be the largest and best function of the year and great plans are being made to have a large number of the Alumni present.

—*F. Hook.*

CIVIL ENGINEERING SOCIETY.

On March 31st the A. C. E. S. again met in the engineering rooms and listened to a most interesting illustrated talk on "Aesthetic Bridge Design" by Professor M. B. Wells. The pictures helped very much to show the gradual evolution of Bridge Design.

The next meeting was called on April 22, and after discussing the business pertaining to the banquet Professor Dean gave a very interesting illustrated lecture on a Hydro-electric power plant in New York. This proved very interesting to the hydraulic and hydro-electric students.

April 28 was set as the date of the civil society banquet, and on Tuesday evening all appeared in the Fraternity Room of the Great Northern Hotel. The banquet was given in honor of Professor A. E. Phillips and suffice it to say that every one came with the spirit that this occasion demanded. The programs were of a very attractive design.

This constituted the last gathering of the civils and marked the close of a very pleasant and profitable year of the A. C. E. S.

E. G. Zack.

FIRE PROTECTION ENGINEERING SOCIETY.

ENGINEERING SCHOLARSHIPS
Offered by the
FIRE UNDERWRITERS' ASSOCIATION OF THE NORTHWEST
to the Students in the
DEPARTMENT OF FIRE PROTECTION ENGINEERING
at
ARMOUR INSTITUTE OF TECHNOLOGY.

PURPOSE:

In general terms, a move toward supplying the growing demand for capable technical men in the fire insurance business.

Specifically, primarily, to interest young men of a high order of ability in Fire Protection Engineering, with a view to inducing them to train for this profession at Armour Institute of Technology; secondarily, possibly to assist deserving undergraduates there to complete their training in that subject.

SCOPE:

Four scholarships are contemplated, preferably one in each of the four years, but with the provision that forfeited scholarships may be either awarded in other ways or canceled entirely as provided hereafter.

Each of the scholarships covers the regular tuition fee only, amounting to $175.00 per year, and does not cover living expenses nor incidentals such as books, laboratory and shop fees, and breakage, etc.

ELIGIBILITY:

Men not less than 18 nor more than 22 years of age at the time of entering college, sound in mind and body, of good address, good moral character, suitably prepared to enter the Department of Fire Protection Engineering at Armour Institute of Technology without conditions or deficiencies.

SELECTION OF CANDIDATES:

(1) Circular descriptive of the scholarships and their conditions to be prepared not later than December 15th of each year for distribution among preparatory schools, Association members and other interested parties.

(2) Application blanks to be prepared and furnished on request for filing with the Association, giving age, birthplace, parents' nationality, details of schooling, professional preferences, business experience, if any, and other qualifications of the applicant.

(3) Applications to be reviewed by the Scholarship Committee of the Association, and members asked by letter to interview all candidates whose applications are judged satisfactory. Committee to discard all applicants unfavorably reported by members.

(4) All applicants favorably considered by the Scholarship Committee to be advised that they will be considered tentatively as eligibles.

(5) Not later than June 1st, applicants remaining on Tentative Eligible List to be advised by letter to send their preparatory school records to Committee if they have decided to take entrance examinations for Armour Institute of Technology. Candidates for scholarships must take September entrance examinations for Armour Institute of Technology regardless of their preparatory school records or certificates. At the conclusion of the examinations candidates will be interviewed by the Scholarship Committee.

AWARDS:

The Scholarship Committee, after considering entrance examination record, preparatory school record, character and personality, shall announce its award in advance of the opening of the Institute year.

Entrance examinations to Armour Institute of Technology are listed in the May Bulletin of the Institute, and copies may be obtained by addressing Armour Institute of Technology, Chicago, Illinois.

FORFEITURES:

Causes.

(1) Change of Course.

(2) Condition not removed by regular condition examinations per Armour Institute of Technology Bulletin.

(3) Any condition of deficiency not made good at beginning of Junior or Senior year.

Disposal.

The Professor of Fire Protection Engineering may recommend to Committee as to disposal of a forfeited scholarship, showing records in substantiation, and Committee may either award in accordance with recommendation or withdraw (cancel) the scholarship for the year, crediting the amount to the Association's scholarship fund.

THE ATELIER.

The most impressive affair of the season was the annual Atelier initiation held in the club rooms in the Institute. The unfortunates outnumbered those of the previous years by many, and kept four executioners busy with the instruments of post-impressionism. The principles of the organization were well stamped on the newcomers' minds and elsewhere.

On Wednesday, Feb. 4, 1914, the Atelier presented Miss Helen Bagg's farce-comedy, "Friday the Thirteenth." In a letter from Mr. Carpenter, the Secretary of the Art Institute, he expresses himself as follows: "I had the pleasure of seeing your play yesterday and I think it the best students' play that has ever been given in Fullerton Hall."

At a smoker on Feb. 12, 1914, Mr. Louis Sullivan was the guest of the evening. He gave an exceedingly deep talk on the "Reasoning in Architecture." Mr. Rebori's ideas were along the same line of thought. Mr. Carpenter addressed the members to some length on various subjects and won a place in the memory of each man present. The usual refreshments and music sent everyone home well satisfied with the evening.

The Annual Atelier dance was held in Blackstone Hall. Some of the work of the Atelier was exhibited around the hall, furnishing inspirations for many dips and slides.

The annual banquet was held at the Sherman House on Friday, May 15. Smokers, as well as matinee, informal dances, in which the architects made the acquaintance of the Art School girls, were held every two or three weeks. The architect's life, as it should be, is made pleasant by the good social fellowship which exists in the organization of the Atelier.

Alumni Department

RADIUM! RADIUM! RADIUM!

The Annual Spring Reunion of the Alumni Association will take place on the afternoon and evening of Saturday, May 23rd, at the Institute.

Your Board of Managers feels especially gratified at the bright prospects for an unusually successful occasion.

During the afternoon there will be a ball game between the Tech Nine and the "Odd Stars." Be sure to be present and cheer for the old ball players and carry them on to victory on a wave of enthusiasm.

There will also be a general inspection of the school and hand-shakes with all your old fellow class-mates and professors.

In the evening besides an unusually attractive and tasty dinner which will be served in the gymnasium where you can ALL smoke if you WISH, there will be an illustrated lecture on RADIUM, by Dr. Patrick O'Donnell. Dr. O'Donnell will give you a most interesting and instructive talk on Radio-Activity, and will perform many interesting experiments with radium. He will also have on hand $40,000 worth of the precious substance, which may be inspected at close range by all. This will really be the opportunity of your life to see, hear and learn about radium—what it is, whence it comes, and what it will do! Dr. O'Donnell has been greeted with unusual success wherever he has given this lecture.

Owing to the extremely large attendance which will undoubtedly be present, your Board of Managers is making

extensive preparations for the occasion. To avoid delay and confusion, the WISE will forward their check for $1.25 to the Treasurer for a reservation.

A hint to the wise is sufficient—nuff sed—ball game—feed —lecture on radium, etc., etc.—all for $1.25.

NEW BUSINESS.

Your Nominating Committee reports the nomination of the following men for officers of the Alumni Association for 1914-915:

For President—Mr. F. G. Heuchling, '07.
For Vice-President—Mr. F. R. Babcock, '03.
For Treasurer—T. W. Simpson, '09.
For Corresponding Secretary—Mr. Paul Greifenhagen, '06.
For Recording Secretary—Mr. Stanley Dean, '10.
For Master of Ceremonies—Mr. T. A. Banning, Jr., '07.
For Manager to 1917—Mr. F. T. Bangs, '13.
For Manager to 1917—Mr. W. B. Pavey, '99.
For Manager to 1917—Mr. H. W. Clausen, '04.

Respectfully submitted,
LeRoy D. Kiley, '12, Chairman.
L. J. Byrne, '04.
F. N. Wilson, '06.
J. T. Walbridge, '09.
A. C. Cramer, '13.

In the transaction of business during the past year, it has been found that same has been somewhat hampered by constitutional limitations. Owing to the progress made and being continually made, it is desired to offer the following proposed amendments to the constitution at the spring meeting.

Resolution No. 1 refers to the creation of a Booster Committee. At present, such a committee has no official standing. In order to increase its responsibility and stability, it is desired to put official sanction on this committee.

BE IT RESOLVED that the Constitution of the Alumni Association of Armour Institute of Technology be, and the same is hereby amended as follows:—

By adding thereto the following, to be designated as Section 4 of Article 9:—

> There shall be a Standing Committee to be known as the Booster Committee. This Committee shall be composed of one active member of the Association in good standing, from each class of graduates, and each such member shall be the Booster Chairman for his class. The members of this Committee shall be elected, and shall hold office as follows: At each regular Spring Meeting and Annual Election those members present from each class shall elect one of the members of their class to be the member of the Booster Committee from their class during the ensuing year; the Vice-President shall fill any vacancies which may occur in such Committee, and shall appoint members to the Committee from those classes which may have failed to select their own Class Members at the Annual Election as above provided. The newly selected members of the Booster Committee shall assume office immediately after the Regular Spring Meeting and shall hold office until the following Spring Meeting, or until their successors are chosen. The members of the Booster Committee shall, if possible, be selected from among those members of their respective classes residing in Chicago or immediate vicinity. The Vice-President of the Association shall be ex-officio Chairman of the Booster Committee; he shall preside over its meetings, and shall actively supervise its work. The Class Booster Chairman from each class shall be directly responsible for the conduct of the Booster Committee work for his particular class, under the direction of the Vice-President. Each Class Booster Chairman may appoint a sub-committee from among the members of his particular class, to assist him in the conduct of the Booster Work for his class, the number of members of each sub-committee being within the discretion of the corresponding Class Booster Chairman. The life of each such sub-committee shall not extend beyond the next ensuing Annual Election.

Resolution No. 2 refers to the Nominating Committee. In order that this Committee may have first-hand knowledge of the work in hand and requirements of the various offices, it is desired that a retiring officer serve on this Committee.

BE IT RESOLVED that the Constitution of the Alumni Association of Armour Institute of Technology be, and the same is hereby amended as follows:—

By striking out the first two sentences of Section 1 of Article X and substituting therefor the following:

> It shall be the duty of the Board of Managers to appoint before the first day of May each year a Committee on Nominations. Such Committee shall consist of five members, one of whom shall be one of the retiring members of the Board of Managers having served three years, and the other four of whom shall be Active Members of the Assocation in good standing; provided that no two members of the Committee on Nominations shall be chosen from the same class.

Resolution No. 3 refers to the Vice President. Inasmuch as under Resolution No. 1 the Vice President is ex-officio Chairman of the Booster Committee, it would undoubtedly be to the best advantage to select him from such a previous committee on account of the experience therein obtained.

BE IT RESOLVED that the Constitution of the Alumni Association of Armour Institute of Technology be, and the same is hereby amended as follows:—

By adding thereto the following, to be added to Section 3 of Article III:—

> The Vice-President shall be selected from among the members of the Booster Committee who have served as Class Booster Chairmen during the closing fiscal year.

RETROSPECT. . .

The retiring officers and managers wish to extend their heart-felt thanks to all the active alumni who have so gallantly supported them in their efforts to push forward the work of the Association.

The arrangement with the Armour Engineer has been an entire success and it is hoped that this success will be even greater during the coming year.

There has never been a time when there was a more brotherly and friendly feeling between the alumni and between the Alumni Association and the Institute than during the past year. This is in itself very gratifying and insures the continued success of this spirit in the future.

PERSONALS.

Herb. Zuckerman ('04) has signified that he is a "live one." He is in San Francisco, Calif., in the potato and onion business, under the firm name of Weyl-Zuckerman & Co. It is evident that an Engineer can do anything. This is what he says to your President:

"Dear Henry:

Very glad to get your foot note on the bottom of the Alumni circular letter and am acting on same. Have sent my $2.00 back to the Alumni treasurer. I certainly try to keep paid up every year and it is only a matter of carelessness in not doing so as my intentions are good.

As you probably know San Francisco is the 1915 city and want you to pass the word along to any of the boys that figure on coming out here to see the Fair to be sure to look me up. California is a grand place to live in and a still better place to visit, and with the added attraction of the World's Fair it is a trip that every one should plan to take any time during the year of 1915.

Here's hoping to see you and lots of the old Armour fellows.

Yours as ever,

Herb. Zuckerman.

P. S. Might add as a P. S. that all is well and everything is going along prosperously with me. It is a whole lot easier to make money out here than it used to be in Chicago when we were both getting up at 4:30 in the morning and peddling the dailies—and besides it is not so cold."

Mr. Charles C. Sampson ('04) is another "live-one." See what he says when approached:

"Dear H. W. C.:

Your personal note noted. Was glad to hear from you if only a request for what has become of me.

I am at present Gas Power Superintendent for the Minnesota Steel Co.

We have here four 3,000 K. W. twin tandem units for power—6,600 V 25 cycles; also, five 45″ x 60″ tandem units driving 84″ x 60″ blowing tube, for the blast for the furnaces. Also, one 500 H. P. unit driving a 2,000 cu. ft. capacity two-stage air compressor for supplying compressed air to the mills.

The unique feature is that we will have no steam engine for starting the job. We are going to use producer gas to start the first blower and when the furnaces get to making gas will switch over to blast furnace gas."

M. J. Douthitt ('08) is a brave man. As soon as he heard that there was a good chance for war, he immediately enlisted in Company A, Engineers of the Illinois National Guard. We take off our hat to M. J. D.

Charles H. Marx ('11) is now a Junior Engineer with the Construction Division of the Bureau of Engineering, City of Chicago. At present, he is working with William H. Dean on the construction force of the Municipal Foundry building.

Erskine Richardson died on September 11, 1908, in San Francisco, Calif. He was with the Ralston Iron Works.

Walter Eyers is now District Superintendent of the Special Risk Department, Phoenix Insurance Co., located at Hartford, Conn. His department handles all the sprinkler business, power plant, street railway schedules, etc., for the United States and Canada except the Pacific Coast.

E. E. Piper is now instructor in mechanical drawing in the Curtis High School, Chicago.

E. W. McMullin is now the Chief Chemist of the Simmons Mfg. Co., at Kenosha, Wis.

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(Signed) F. W. HOOK,
Business Manager.

Sworn to and subscribed before me this 24th day of November, 1913.

JULIA BEVERIDGE,
Notary Public.

My commission expires Jan. 8, 1918.

ALPHABETICAL INDEX OF ADVERTISERS.